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SMT007 MAGAZINE

Practicing Best Practices

While it is not set in stone, following best practices helps ensure manufacturing excellence. This month's issue of *SMT007 Magazine* looks at best practices in the PCB assembly industry and how to incorporate them into your own manufacturing environment.

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We Have the Best Practice for That

Editor's Note
by Stephen Las Marias, I-CONNECT007

Every industry has its own set of best practices. When I was working as a clerk in a fast food restaurant during my college days, the prep station—which is where the different foods to be cooked are prepared—had a big signboard reminding everyone to use the recipe cards when preparing the many different items in the menu. Of course, those who may have been working there for several months already had likely memorized the different ingredients needed for all of the meals on the menu. But people are not perfect. Often, not following the instructions as per the recipe card resulted in a sub-standard portioning, or bad taste or texture of the food, if not worse.

This is why the best practice in that particular situation is to make sure that the recipe card is right in front of you when doing the job.

The same goes in the manual assembly lines of all contract electronics manufacturers. One of the EMS facilities I visited has a separate room where the wave soldering process is being done. In that line, a group of operators are inserting through-hole devices and components into boards before they send them to the wave soldering queue. These operators have in front of them a variety of instructions regarding the components for that particular board, the picture of the component, its dimensions, and how it should be placed or inserted on the board, and more. Even though the operators at the end of the line are just inserting a connector or two into the boards, they still need to make sure they have the instruction cards—as a best practice—to ensure the correctness of the job they are doing.

These are just a few examples of why everyone should have some best practices of sort when it comes to the many different aspects of their operations, especially in the electronics manufacturing industry. Imagine if you're supplying for mission-critical applications where product failure is not an option.

I believe most best practices have been developed over time, based on the many different experiences that people encounter in the manufacturing line. Some may have been set in stone from day one, but others likely were borne out of the many realizations and conclusions, perhaps after a post-mortem or evaluation of the results of the process. Some may have been passed on from generation to generation of workers as some sort of tribal knowledge.

Be that as it may, it is important to institute these best practices to

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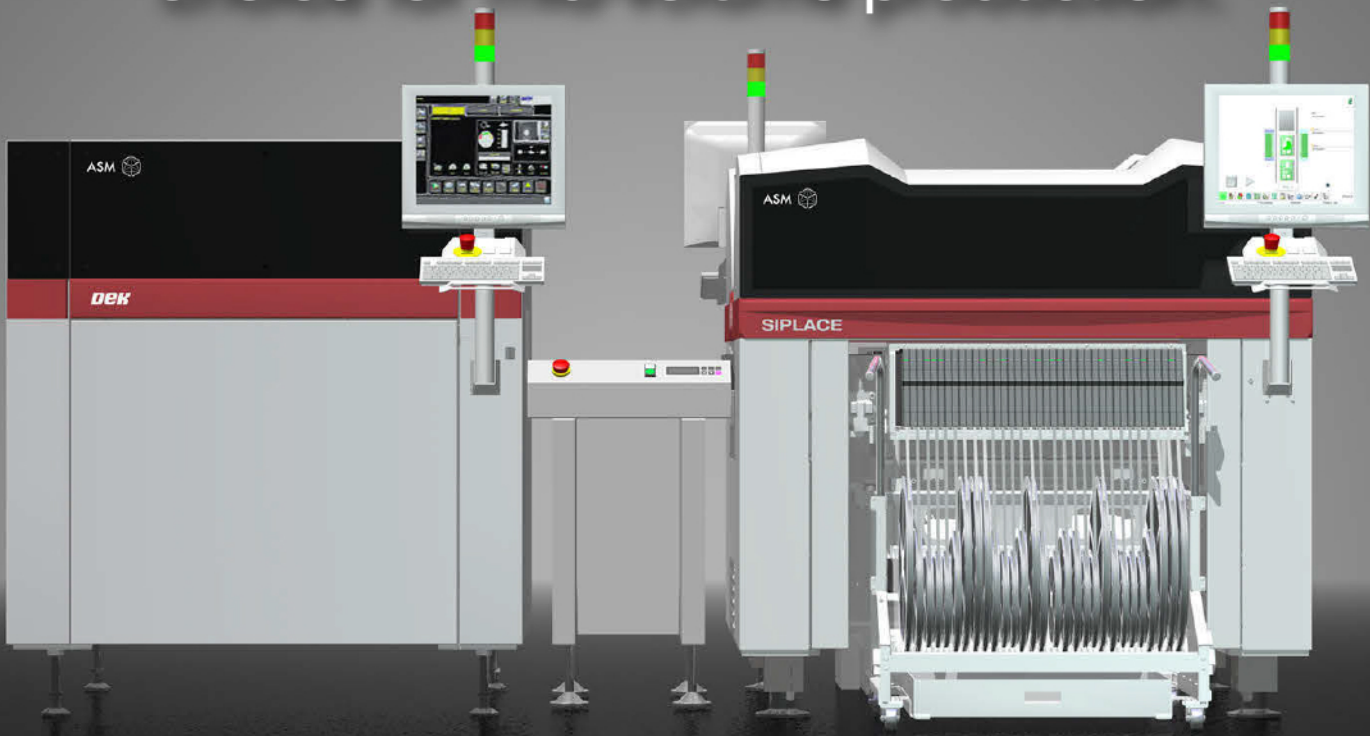

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Which brings me to this month's issue of *SMT007 Magazine*, where we highlight the many different best practices to consider for the many different aspects of electronics assembly. Of course, they may not be the correct solution for your every manufacturing issue, but at least it will be worth considering these techniques, concepts, and how they may be applied in any situation.

For starters, industry experts Bob Willis and Celestica's Jason Keeping discuss the many challenges in PCB assembly, from the education side all the way to the different processes; what they think the industry should be doing; and the best practices to consider in the many aspects of PCB assembly.

Next, Craig Stott, Ed Sermanoukian, and Girish Wable of Nypro, a division of EMS firm Jabil, provides an article about the different assembly methods for medical devices, and how to optimize the design for assembly (DFA) process.

When it comes to choosing the correct solder paste for successful electronics assembly, Jason Fullerton of Alpha Assembly Solutions has quite a bit to say about the topic in his feature article.

Brian Morrison of Vexos Corp. highlights the best practices in wave soldering, while Stephanie Weaver of Zentech Manufacturing wrote about the task order execution essentials in contract manufacturing.

East West Manufacturing's Patty Rasmussen, meanwhile, tackles demand forecasting—having the insight to know what you need before you need it. On the other hand, Sandy Kolp of Firstronic discusses how cross-functional teams can drive strong focus on risk mitigation and quality.

I am happy to welcome our new columnist, Eric Camden of Foresite Inc., who will be writing about PCBA reliability issues and preventing suspect conditions in the first place. Dr. Jennie Hwang continues her column series on the role of bismuth in electronics, while Bob Wettermann explains the ins and out of replating gold contacts on PCBs during rework.

I hope you enjoy this month's issue of *SMT007 Magazine*. In the next issue, we will tackle the megatrends impacting the electronics manufacturing industry this year. **SMT007**

Stephen Las Marias is managing editor of *SMT007 Magazine*. He has been a technology editor for more than 14 years covering electronics, components, and industrial automation systems.

Vertical Gallium Oxide Transistor High in Power, Efficiency

Cornell engineers have made a breakthrough in semiconductor transistor research that offers the potential for high-power electronic applications along with reduced power consumption.

The research has demonstrated metal-insulator-semiconductor field-effect transistors (MISFETs) with record performance using a new material. Gallium oxide has emerged in recent years as a desirable material for semiconductors in high-power applications. Its chief characteristics–a wide bandgap, more than four times that of silicon, and availability of large-area perfect crystals–make it an attractive alternative to silicon for high-power electronics.

Professors Huili (Grace) Xing and Debdeep Jena from the departments of Electrical and Computer Engineering (ECE) and Materials Science and Engineering (MSE) presented a series of these findings at the annual Compound Semiconductor Week (CSW) held in Boston. Zongyang Hu, a postdoctoral researcher in the Jena-Xing Group, is the lead author.

The group used hydride vapor phase epitaxy to deposit a 10-micron layer of silicon-doped gallium oxide onto a gallium oxide single-crystal substrate. Their methods and measurements, detailed in the paper, produced a vertical power, enhancement-mode MISFET that featured breakdown voltages of greater than 1 kV, as well as an attractive on/off ratio.

According to the paper, gallium oxide's expected critical electric field exceeds that of silicon and gallium nitride.

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The Role of Bismuth (Bi) in Electronics, Part 3

SMT Prospects & Perspectives

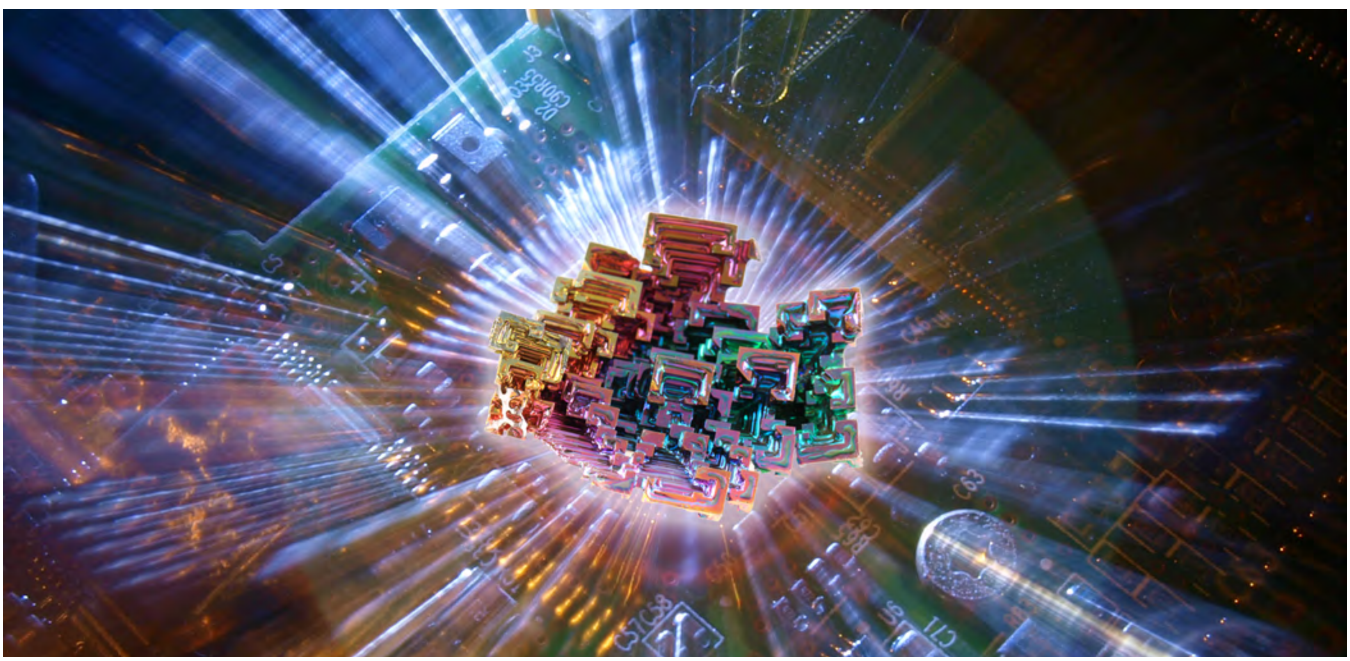
by Dr. Jennie S. Hwang, CEO, H-TECHNOLOGIES GROUP

Part 3 of this series focuses on how Bi plays a role to the answers of these two questions: Why isn't SAC able to be a universal interconnecting material for electronic circuits, and why does a quaternary alloy system offer a more wholesome approach? (Note: a quaternary system referred herein does not include SAC compositions incorporated with one or more doping elements.)

Overall, SAC305 has performed to expectations—delivered satisfactory solder interconnections for most (but not all) applications under most service conditions. Nonetheless, some performance deficiencies have manifested as anticipated. Specific deficiencies include the undesirable brittleness (loosely defined) relative to SnPb counterpart and the potential occurrence of solder joint surface cracks and other production-related defects and issues (e.g., head-on-pillow, pad-cratering).

One straightforward remedy to alleviate the loosely defined brittleness of SAC305 was to reduce the Ag content, which consequently has led to the introduction of low-Ag SAC alloy compositions (e.g., SAC0308 containing 0.3wt%Ag, 0.8%Cu) to the industry. Apparently, the reduced metal cost of the low-Ag compositions also offers an upside. However, with the reduction of Ag content, the mechanical properties of resulting solder joints (the yield strength, tensile strength and creep resistance) are expected to decrease. In the ranges of Ag and Cu contents of this discussion, the fatigue resistance, which often involves more complex mechanisms, is also expected to decrease with the reduction of Ag content.

Testing measurements coincide well with the expectations. For the effect of Ag content (at a range of 0.5–1.5 wt% Cu), tests showed that yield strength and tensile strength increase



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almost linearly with Ag up to around 4.0 wt %; and its plasticity increases with decreasing Ag content[1].

Overall, the lower strength is associated with lower Ag content, in congruence with the metallurgical principles. When an alloy delivers (or fails to deliver) its performance over a period of service time in the fashion largely in line with the expectations before a single test was run, it is immensely comforting and rewarding.

When an alloy delivers (or fails to deliver) its performance over a period of service time in the fashion largely in line with the expectations before a single test was run, it is immensely comforting and rewarding.

Turning to manufacturing processes, which in turn affect the integrity of the circuit board assembly as a whole, the alloy compositions containing the Ag content lower than 3.0 wt% (SAC305) correspond to increased liquidus temperatures comparing with SAC305. The liquidus temperature increases with the decreasing Ag content, which is nearly in a linear correlation. This was also expected, because SAC305, a near-eutectic composition, essentially is associated with the lowest melting temperature (217–220°C) that can be achieved within the SnAgCu system.

Does that few degrees delta in liquidus temperature matter? The answer is resoundingly a yes.

The increased liquidus temperature requires an increased process temperature to make sound interconnections in the package level or board assembly level. The increased liquidus temperature also demands a higher level of heat resistance of PCB material and PCB internal structure. By any practical measures, all materials and components used in the assembly must have a higher temperature tolerance level in order to be in sync with the process temperature dictated by the lower Ag content.

It should be noted that the liquidus temperature of SAC305 already pushes to the high end of assembly temperature in order to fit a broad spectrum of PCB designs under the current SMT infrastructure. A melting temperature below 213°C is more desirable and forgiving, providing a wider process window. To avoid a "narrow" process window is the prerequisite to minimize production defects.

Specific constraints in the SMT infrastructure including the supply chain have been established in the industry. With the goal of meeting the relentless demands of enhanced performance of electronics, a ternary alloy, such as SAC, is expected to fall short in serving as a reliable interconnecting material to deliver all properties and performance that the advanced electronics requires, particularly the thermal fatigue resistance to withstand the stress/strain that powerful components imposed on the solder joint. The same applies to other ternary systems.

Under the known constraints of the SMT manufacturing infrastructure (e.g., operational flow, process temperature) and the requirements of physical and chemical properties of materials to produce electronic products (e.g., environmental stability), ternary systems unfortunately do not possess the fundamental microstructure and metallurgical foundation to support the higher level of solder joint performance and solder joint reliability.

Advanced electronics designed with higher functionalities and higher power in a smaller form factor imposes a larger amount of "cyclic thermal stresses" on solder joints. This was the genesis of designing quaternary alloys, as addressed in the early 1990s in many of my professional development courses and publications.

It is worth noting that the scientific base to design the SnAgCuBi system was not to add an element (in this case, Bi), to an SAC system. Rather, it was a holistic material design platform using the underlying science and engineering of metallurgical interactions and taking the commonly-occurring solder joint failure mechanisms into consideration. In other words, the design was to mitigate those likely failure mechanisms so that solder joints, by serving as electrical, thermal and physical conduits in chip level, package level and on circuit board, can reliably connect powerful semiconductor chips to the outside world to make reliable advanced electronics that we all enjoy using in all facets of our lives. **SMT007**

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About the Author: **Dr. Hwang,** an international businesswoman, international speaker, and business and technology advisor, is a pioneer and long-standing contributor to SMT manufacturing since its inception, as well as to the lead-free electronics implementation. Among her many awards and honors, she is inducted to the International Hall of Fame for Women in Technology, elected to the National Academy of Engineering, and named an R&D-Stars-to-Watch and YWCA Achievement Award recipient. Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., SCM Corp, and IEM Corp., she is currently CEO of H-Technologies Group, providing business, technology and manufacturing solutions. She serves as Chairman of Assessment, on the Board of DoD Army Research Laboratory, on the Commerce Department's Export Council, on the National Materials and Manufacturing Board, and on various national panels/committees, Fortune-500 NYSE companies, and civic and university boards. Hwang also holds various international leadership positions. She is the author of 500+ publications and several books, and a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees as well as the Harvard Business School Executive Program and Columbia University Corporate Governance Program. For more information, please visit www.JennieHwang.com.

Jigar Patel Discusses ZESTRON's Reliability Solutions for Class 3 Assemblies

At the recent SMTA West Penn Expo held in Monroeville, Pennsylvania, I-Connect007 Managing Editor Patty Goldman had a chance to discuss a paper presented by Jigar Patel, senior application engineer at ZESTRON.

Most of the Class 3 assemblies are used in aerospace, medical electronics, and similar areas where they need long-term reliability. These products should perform for certain time under all the conditions. Take, for example, a pacemaker. Once they put the pacemaker inside your heart, it should work for a minimum 10 years without replacing the battery. If you have any residual contamination inside the circuit board that is going inside the pacemaker, it will create leakage current. You need to ensure there is no contamination present and the battery does not drain out. This is just one example.

Patel explained the reliability challenges for the Class 3 assemblies and how Zestron can help them if they're cleaning their boards.

Read the full interview here.

Practicing Best Practices

Feature by Stephen Las Marias
I-CONNECT007

This month's issue of *SMT007 Magazine* looks into electronics assembly best practices that help optimize our manufacturing processes. For starters, we interviewed two assembly experts: Jason Keeping of EMS firm Celestica, and Bob Willis, a renowned EMS consultant and trainer.

Keeping is a member of Celestica's Corporate Technology department. Within Celestica, he is the subject matter expert on ruggedization, which includes all of the different processes around assembly cleaning, underfill, conformal coating, and plotting—"the stuff that you need to do to make things last in harsh environmental conditions." He is also the chairman of the Aerospace Hub for Canada's Education Program, as well as the president of SMTA Ontario.

Recently, Keeping just became the chairman of the IPC 5-30 Segment, which covers most of the technologies and standards for cleaning and coating.

Willis, meanwhile, started his career as a young engineer at GEC Marconi in assembly and PCB manufacture. He then went into research with GEC Marconi, now BAE Systems, and then into contract manufacturing for a couple of years. Within these companies, Willis did failure analysis, training provider in the company, surface mount assembly and environmental testing. For about 40 years now, he has been running his own business doing training consultancy worldwide, a majority of which is now online with webinars, which he does for a lot of corporate companies as well as the technical sector such as the National Physical Laboratory (NPL), SMART Group, SMTA, and others.

Stephen Las Marias: From your perspective, Jason, what are some of the biggest challenges that you can think of in electronics assembly when it comes to the human factor, equipment, and manufacturing technology?

Jason Keeping: The biggest challenge, I think, for the human factor is a lot of global work with a transition to lower-cost geographies. The retention is not as long as a lot of our traditional higher-cost geographies, so as you try

Jason Keeping

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AKILA | MS2® Molten Solder Surfactant | pkaymetal.com | +1 323-585-5058 | PK METAL to move some of the complex or more experience-based products, this becomes a challenge because that experience is not there because individuals are not with companies.

Regarding equipment, minus some of the leading-edge applications, equipment has been pretty well on par meeting newer demands about miniaturization. Some of these lead technologies are outside of the scope of microelectronics, I'd say. We at Celestica were aware of this challenge several years back and we've been investing people, space and equipment, so we can get to that new advanced articles for technologies for equipment.

Now, I think the biggest challenge is manufacturing technology. Not because of similarities because the manufacturing knowledge does the same in the path as equipment both getting smaller components and higher quality targets. The trends that I see that are putting the challenge on the electronic assembly industry is one of transition from tin-lead to lead-free, electrification and miniaturization. Miniaturization, we cover really from the equipment point of view. Let's say when we talk about transition from tin-lead to lead free, there's a challenge that was well taken both by equipment and cross technologies, a lot of new materials developed, new placement and equipment manufacturers and new reliability curves and review.

But that last part, the new reliability curves to discuss more in recent years. What I'm referring to is tin whiskers. When we start looking at some of the high-reliability products such as satellites, radars, pace makers, nuclear power plants, some of that technology we can't really move forward to lead free because we don't have those reliability curves in place.

Now, the other thing around manufacturing technologies, which is more at my heart, is the challenge of electrification. It's not that we're not aware of how to do ruggedization. Many companies in the industry have been doing it for years, decades, even almost a century protecting components from harsh environment conditions. But, with the transition of these components into these non-historical harsh markets where you previously had no electronics or now we're adding additional electronics that weren't present before, this is a challenge that I see a lot more customers asking how and what to do.

Examples are products that were not previously in harsh conditions were a lot of datacenters and telecommunication switches—they were always in embedded, closed environmental structures, which now they're opening up and going into different geographies. Then you look at other things where we're now adding electronics to products that were already designed for harsh environments, such as new sensors in automobiles, a lot more displays in goods like washing machines and dishwashers. There's now these added electronics that weren't there before.

Bob Willis: Jason has highlighted a lot of the issues. My take on a lot of this is really we lack the depth of education in many different sectors. We find that in a lot of companies, you have some highly qualified people working in design and manufacturing, but we don't have

Bob Willis

the same sort of skill sets or knowledge and there's sometimes reluctance to pass on that information to production line personnel. They are the eyes and the ears of a factory and can solve many issues if we give them the tools.

I think that the one thing that's missing certainly that I see in the UK and obviously in some parts of Europe is the ability for people to get that information. Of course, now there is a rich source of information online, you just have to look and decide what's relevant and what's not relevant. But we've never really had a very good education system, my opinion, for bringing those skills on board. It's only in the last 10 years, certainly in the UK industry, that we're going back to apprenticeships. Those didn't exist for a decade, and now they're becoming more popular again with companies because the companies are being told basically to do it by the government.

If you look at technology, there's always challenges and as Jason said about lead-free technology, but boy, have we wasted a lot of money, a lot of effort in doing something that really didn't see a benefit. You know, there's people that promote lead-free technology and those against lead-free technology, but the reality is it never did what it's supposed to do—which is really improve the environment. We're using materials, and we have used materials which, theoretically, if we put them on a table we wouldn't have wanted to use them because they are more detrimental to the environment than lead ever was, but that's a politician discussion.

If we look at manufacturing equipment, I think that we have some incredible equipment available to us. Engineers, including process engineers, have phenomenal tools as long as they can afford them, as long as they can have access to them and implement them into their production lines. The model that contract manufacturers really took on board, by setting up centers of excellence on personnel and equipment so they can then push out the technology and information they've learned, setting standards to all their different outlets and bases, and their different geographical locations, is perfect.

But if I step back, say 40 years ago, the only company that really did that is Phillips, in Eindhoven. There was just one company that had a center there which, if they wanted a new piece of equipment, a new printer, a new dispenser, a new reflow oven, there would be a queue at the door to give them free equipment. They were then able to use that and say that's good, that's bad, that's good paste, that's good coating material, to all of their different satellite organizations.

That's kind of what the larger contract manufacturers are able to do. I just wish that some of the smaller companies who have lots of manufacturing sites could also do it because that would improve good implementation and technology and, as this discussion is all about, good practice. I wish I had had the scope and opportunity to replicate this when I was surface mount coordinator for GEC.

Las Marias: You mentioned education. I think, as more and more new technologies come to fore, for instance Industry 4.0, Smarter manufacturing, there is definitely a need for higher skills when it comes to the production line. Would you agree to that?

Willis: Yes, absolutely, and I think that Jason would agree as well. You've got to think across the board. When I'm working with companies, I do come up against situations where they've got the nice equipment, but that's all they do. They look at the numbers, they look at the statistics, and some customers in contract manufacturing do exactly the same. They're interested in the numbers rather than looking at product. You've got to do those two things. Recently, I was working on a production line where they had a particular problem and said, well you know our machines don't tell us this, AOI or SPI doesn't indicate. I said to them, "Have you looked at the boards?" And then they look at me with a face that says, "What are you talking about? These machines do all of that."

No, they don't. They help you to do your job better, they help you to look at more data and more information. The bottom line is, if you've got an issue, a problem, look at the product. The product is going to tell you whether it's this or that problem. I think, if engineers don't do it, then certainly process techs on the line have to do that. It's up to us as engineers and managers to give them that experience. That is very difficult to do. If you've got somebody that is working in a particular process like conformal coating for more years, probably then you'd remember.

You can't pass on all of that information. The "Oh dear, that's how I solved the problem two years ago." It's very difficult to do that. That's why, obviously education is beneficial, but more and more good reference sources are. If you take an example of your organization, you have put together books for people to read, to be able to download. That's a useful resource. Those sort of things, as long as they're seen as valuable, they have good information. Then people will pick them up. They will use them and they will reference them. It's finding a way of disseminating as much good information as possible to all departments.

Finally, on that point, if I may, it's the same thing for customers as well. It's always surprising me that customers don't learn about their product, their process, but they come into a facility and criticize things, an audit, or criticize particular things that have happened without understanding the real world. They often say to me, "Well, we don't need to know that, we only want to know how many units are coming and when they're coming." They're there, they have their quality engineers to solve problems. They don't really want to get involved with the nitty gritty, which I think is their loss. And as a communication source, a disadvantage to them as well.

Keeping: I'll just add one small complement to what Bob said, and it's a quote I've seen somewhere. I'll have to remember what the quote was, but you look at the current generation of workers, which are the new, and you look at the previous generation of workers, which are the experienced, and then they look at, let's say Google—they think that the new generation is more educated and they can just go and


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get things they want, but they forget a lot of the basics and the fundamentals, which is where a lot of that experience comes from because we designed and put all the stuff in place for you to say "Google, ask me this," or "Google, search this."

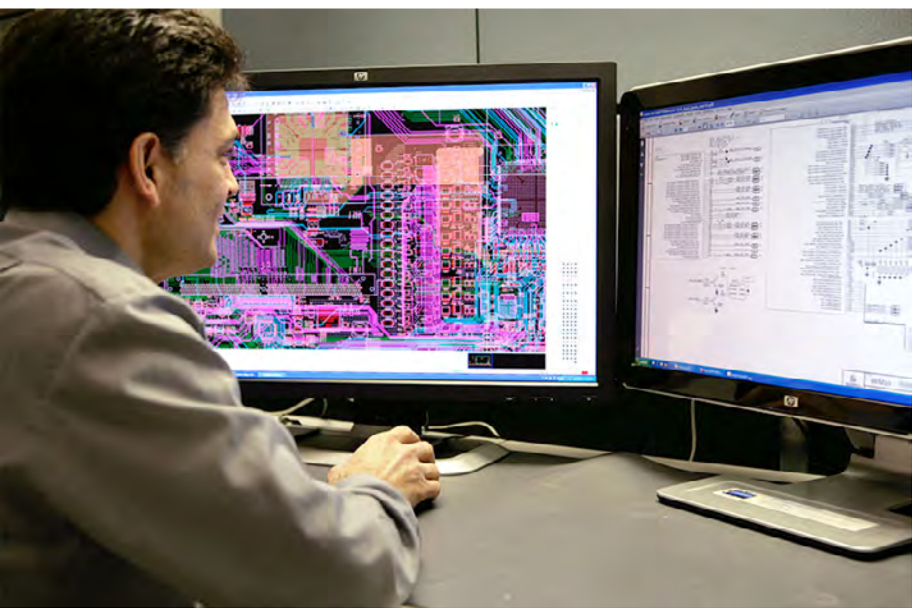
They think a lot of those answers are just there, the equipment does it, this does this, and they forget that a lot of that experience has to be there to understand the full product so that you know what you're doing, and if something is wrong, you know where to look.

Las Marias: Right now, as a lot of the older generation will be leaving the industry and the new generation, those coming out of college and those that are, let's say five to 10 years into the job, they will be the leadership now. I think the experience is very important for the continued success of the organization.

Keeping: Correct, and I think I confirm what Bob said earlier. I remember when I first started, I didn't see as much education that was being available as I see now. As we're talking about a lot of these technologies that I'm referring to, let's say about ruggedization. we now have a clean and coating conference that happens every two years, but it only goes back ten years. For people 20–30 years ago, that available knowledge was not there. IPC and SMTA have got a lot more mentorship and young engineer programs now. Those weren't there five or 10 years ago. There is a push to get that next generation speed, but you can only push so much. You also have them wanting to desire it as well.

Las Marias: In our conversation with other industry experts, one of the key things that stood out for us also relates to what Bob mentioned earlier about the communication between the manufacturers, the equipment suppliers and their customers. More and more I think now it's very critical for these stakeholders to work closely together even as early as the design stage for the manufacturing success of their products. Would you care to comment on that?

Willis: Sure, just a starting point to lead into that. One of the things that I remember, this is again centuries ago when I was young, we did a program—you know this is not rocket science and I'm sure it happens in other parts of the world—where we made sure that some of our engineers working in PCB fabrication spent two or three weeks working in assembly, and vice versa. Those guys worked in PCB fab and their operation was about 600 people, and there was like 50 people in each of those different departments. That seemed very, very reasonable to us. Then, because we had a local college that most of our students were going to, we wrote whoever was the boss there at that time and said, "Look, what we would like to do is have one or two of your lecturers spend their summer vacation actually working in manufacture."



Because all of our students and our students in the future will be coming through and we don't want to just have the standard textbook view. We want to know what happens in the real world and this is pretty much the same in any industry for fabrication, component handling, wire wrapping, preparation—all the sort of core tasks we talk about today. We want you to spend some time in those areas, so you can better educate and pass on information in the future. That's something I think doesn't happen enough within the industry. If we then go to customers, and I'm sure Jason has come up against the same things about designers throwing the design to the production people, throwing the design to the quality people, and on and on and on—but it happens so much with customers as well.

They pass on information to a contract manufacturer, and it's only the good contract manufacturers who say, "Hold on a minute. I want to sit down and talk you through this. I want to make sure that you understand, we're going to build this. We're going to build it to this level of quality or whatever. We can achieve what you want, however these things need to change or these parts need to modify. We need to work together to achieve that."

There are, I'm sure, quite a lot of products that contract manufacturers are offered that are turned down because they're not going to see a successful product build in the future, so consequently they're taking on something where they may make money but it's not going to be a long running product. They're investing time to make sure that the customer is successful, and the customers spend time, which very often they don't, in making that investment with their suppliers, and that just doesn't happen enough.

Las Marias: Being a contract manufacturer, Jason, do you talk to designers to make sure that whatever design they throw out to you guys is manufacturable? That there's no need for a radical change in your assembly set up to be able to adapt to whatever design is thrown out at you?

Keeping: I think I really just compliment the way Bob said it, but if I go back to best practices and you start looking at DFM, most of the time when conformal coating or other ruggedization are thought out, it's not because they've thought of it in advance but because they've had a field failure, a test did not pass, or they just want to make something better. Then they look at conformal coating or ruggedization.

At this point, we're doing the DFM for ruggedization, but how do we get the new capabilities to work with current products and designs? What I mean is, a lot of the times as we're looking at the products the customer wants to understand how to get it to the field better, but do they know when they're at a design stage what's going to be that final end environment? What does the product need to work in? What are the convections that might inhibit this function or cause failure?

What ruggedization is required? Do you need to do assembly cleaning? Do you need to do coating or plotting? How do you select all the right components? As we switch from tin lead to lead free, there's a lot of components that are designed different. You try to do this capability, and it actually will affect their functions and working capabilities. Then as you design a board with those proper components and that right process in mind, that would give you that additional longer life and higher reliability. A lot of the times when a customer first looks at a product they're looking at just the cost alone but usually not the total cost of ownership, how to get all of those capabilities done at the design stages before it gets to the EMS provider.

Andy Shaughnessy: A lot of designers say that they're designing with the fabricator and assembly facilities' capabilities in mind, but they're swamped and behind schedule, so they do make mistakes. Form what I've heard from fabricators, most design errors tend to be mechanical, not electrical, like putting something too close to an edge.

Keeping: I completely agree with that, and remember, usually the designer will have, let's say, an electrical background or design knowledge. They're not assembly experts, they're not a ruggedization expert, so they've got one scope or one set of glasses that they're looking at to solve the problem and, of course, they're going to use that to their full knowledge. But if they don't share that with that other expert, then they've only got half the information they need to get the best design for the first time.

Willis: I think that every company should have some form of DFM review, even if it's just 10 people. You look at the product, you look at it as it goes through manufacture, and you make a simple note about what worked and what didn't. If you pass it to another department for cleaning or for coating at the initial prototype stage and get them to sign it off in some way to confirm it is manufacturable or to confirm what needs to change..

That sort of stuff doesn't exist in a lot of companies, going back to find out who looked at this, who decided on that. That information's not available, but when you're creating a new design, however you're going to do it, all the information needs to be kept together. And so often when you do failure analysis, as I do all the time, you say, "Okay, where is that product going to go? What procedures need to be followed? Where is that information? Where are the test results?" Just recently, I had a corrosion failure. This product was designed to be in an automotive application, exposed to moisture, and they didn't have conformal coating included even though it was obvious that condensation would take place. It's not obvious it's going to have a failure, but it's obvious the condensation was going to take place. Because the customer did not ask for coating, no one questioned the potential for failure.

Potentially, we might have corrosion, which they've actually got. I said, "Okay, what did you do? Did you test it?" "Yeah, we tested it, this is a special occasion our customer wanted us to test it to." But it's not relevant for what they're doing. That company is taking reliability of that product they're building without fully understanding, or the customer understanding the potential risks. Now, there's some argument whose fault it is. I would say, "Well, sorry guys, you haven't followed it through properly and that's the reason you've got a problem."

Las Marias: Speaking of particular processes in the assembly—material handling, paste printing, component placement, soldering and conformal coating—Jason, what are some of the best practices that you can talk about?

Keeping: I think you had a very good list there. If I look at your first topics here, material handling, paste printing, component placement, reflow, soldering, they're not my areas of expertise. I'll probably leave that for Bob to talk about, but all of these processes do have a common aspect that does lead into my area of expertise, and this is assembly board ionic levels.

With the conversion to no-clean, I just want to say right there that's a myth that was started. The assembly cleaning was no longer required, however we still have low levels of ionics present. I prefer to say "low solid materials". Based on the format of these processes these can even still be very high and even excessive to the point of source ionic failures later in the process or in the field, such as mate-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about workmanship. Where is coating required? Where is coating not required to be present? The key aspect of both those two are what are the tolerances? When you have a connector and then you have a line that goes up to the connector body, well is a splash on a connector body acceptable? These types of discussions have to happen. Then you look at inspection limits and magnification. IPC only has up to 4X, yet a lot of people will look at soldering and then conformal coating under a microscope and they find all these defects that might not actually be defects as looking after conformal coating. Repair—is it allowable, or is it not? If it is allowed, what are the conditions? Is there an approval process? When you start looking at all this and you're developing an optimal conformal coating factory for productivity as well as operator safety, what do you need in place for best practice?

rial handling. Is it open to the environment? Could your areas have humidity or temperature control that could cause failure when you're doing paste printing? During the reflow, especially under low standout components, is all the flux activated? When you start looking at component placement you look at the larger companies versus smaller companies, is it all done manually? Are they using gloves? Do they have finger oils and residues that are transferred from product to product?

Then with wave soldering, is there any inactivated flux? Do either the tooling or the low standoff pin through hole components or from the thermal profile that's used that doesn't activate all the flux that might be hidden? All of these areas are potential locations for ionics to be added to the board which would then get down in the field for what I look at ruggedization. If they're not cleaned they could produce field failures like Bob listed earlier about corrosion.

Now, when you start looking at best practices of conformal coating, the first thing is to select the conformal coating material. Not really for what's the cheapest available, which unfortunately is what a lot of people do, or what is the material we have in house? We should use it for this other product. They need to look at what's the lowest total cost of ownership for a product life cycle, not just the individual product cost to produce that device.

That's one key aspect. The other one is, as we were mentioning earlier, you need an agreement between the user and the customer

Is it a single-piece fixture flow? You've got to make sure you have all the appropriate Kanbans. The coating application system you're going to use, does it meet customer requirements as well as manufacturing targets? All the process controls that are used, are they both available and are they correct? Sometimes, people are like, "I've got process control. I get this value in line." But it might not be the right process control you need to make sure you're using the correct ones. Some of the key stuff is DUEs and CPKs. Did they do that at the very beginning of a process implementation review to make sure they get the most robust process so that every product is done with the best reliability and best repeatability?

Then, is there a final report that's available that says all of these parameters and everything is documented showing that all the requirements are achieved? Above all of that, anyone that's then doing conformal coating or some other types of ruggedization, how do you know what you're getting? How do you know how you're controlling it and how do you figure out what needs to be done and discussed so that you can get to that point? I think those are the key aspects I look at for best practices.

Las Marias: What do you think, Bob?

Willis: Well, you could spend a day talking about each one of those issues, so I think we've got to be general about it. I mean, exactly what Jason has said that, unfortunately, when you delve back into the information based on a new product, so much information is never available. It's never been documented, it hasn't been evaluated, if we talk about cleanliness and corrosion and things like this.

Like I said a moment ago, I've just been looking on some failures on automotive specifically on corrosion. When you then ask the questions to get the information, "Was testing done?" "How was it done?", all of that information is just like a fluid sand bath. It just melts away because it hasn't been done. The steps in any process need to be considered. I like to do things on a very practical level to start off with. I like to get something in my hands, I want to feel it, I want to touch it and I want to test it in that right. Then I decide, how can we test this so it meets an IPC/IEC standard? What's the methods we can use? If we look at something I have been involved with recently looking at condensation testing for PCB, for cleanliness and conformal coating compatibility with NPL.

The existing tests really don't give you perfect consistency on results and the test developed particularly for the automotive industry, the Dewing Test, which was being conducted for many years in Germany really again gives more failures than positives. Probably because of the way the test is done. There is no control and repeatability over the amount of moisture introduced onto a surface. Even a pretty clean surface can actually have failures, but not because of what we've handled. Not because of what flux we've used. It's literally the material condensing on a surface, and because you're getting a large amount relatively speaking, droplets, in certain areas, that's why we're starting to see issues. I think that the way in which we do test needs to be continually reviewed, and that's what IPC does. They continue to review tests to see how they can get better and better and better.

I started off my career testing components for cleaning compatibility with water and solvent. If we look at cleaning as a subject, if you look at most components today, if you look at specifications, because many engineers have grown up in a no clean environment, you ask them about testing components and they look at you blankly. You ask a designer, "Have you tested this component and is it compatible?" Because you want to have this product cleaned by your contract manufacture, and they'll look at you blankly. Another thing, and it's no disrespect, I

probably would do it myself. You look at when people look at components they look online, which is the Google search. They download the component documentation from the supplier and believe what it says.

If you take just an example of QFN, quad-flat no-lead components, the people designing these into boards were following what was said to them by the component supplier, until the contract manufacturers and assemblers said, "Hold on a minute, this isn't going to work. It isn't good practice." Hence, you've had all this work done on stencil thickness and modification to improve processing, but it all stems back. The one thing I'd say to designers, if you're going to pick up on a new component to use, look at the data from the supplier, that's fine. If they've got a few micro sections and if they've got a little bit of other data on their profile, but they've actually got pictures of what they did, you know they've done some technical work. If they've got a spec which is set by the IPC, or this is maximum/minimum temperatures, you've got to query whether they've actually done the work to prove it. I always say look at the data, look for more than the data, and you'll get a better feeling.

If we talk about, let's say, wave soldering, it really hasn't changed radically for many, many years. The wave soldering process can still do a good job, but it relies on the people setting it up properly and watching what's actually going on. Wave soldering design is also critical for good yields, and there are so many tricks of the trade in design to improve yield. However much we would like to fully automate the process, that just really won't happen. There was a machine once which was a totally automated, computer-controlled machine made by a company. There's only a handful of those machines that were actually used in the real world because you couldn't actually do very much with them.

Selective soldering, we have the ability to control and monitor a lot more. We can control and monitor warpage of boards so we can get better optimization. There's lots of things we can do there. If we talk about reflow soldering, there's been things that have changed to improve on optimization of cleaning, optimization of gas transfer, and things like that, but the actual fundamental of the machine when we went from infrared technology to convection technology that was the major leap. There wasn't really much that can change with convection technology. You get to a limit, its capability. The machine has to be a certain length to get a certain number of products through in an hour, and that's it.

You can look at things like power consumption, etc., but then you look at vapor phase process, because you're using a lot less energy with vapor phase, you've got more control of your process. As long as you can run it for the product volume you want to run, that's a much more attractive process. There's lots of toys that us engineers have to play with. We select the best tools to do the job. Really, that's what that best practice is all about. The best tools to do the job and then put in the procedures to make sure that people follow and get the best out of their machines.

It's not only that, it's listening to people. If I go into a factory and I'm trying to solve a problem. I'll hear all the sort of introductions and listen to what everybody tells me, but I'm going to go down on the shop floor. I'm going

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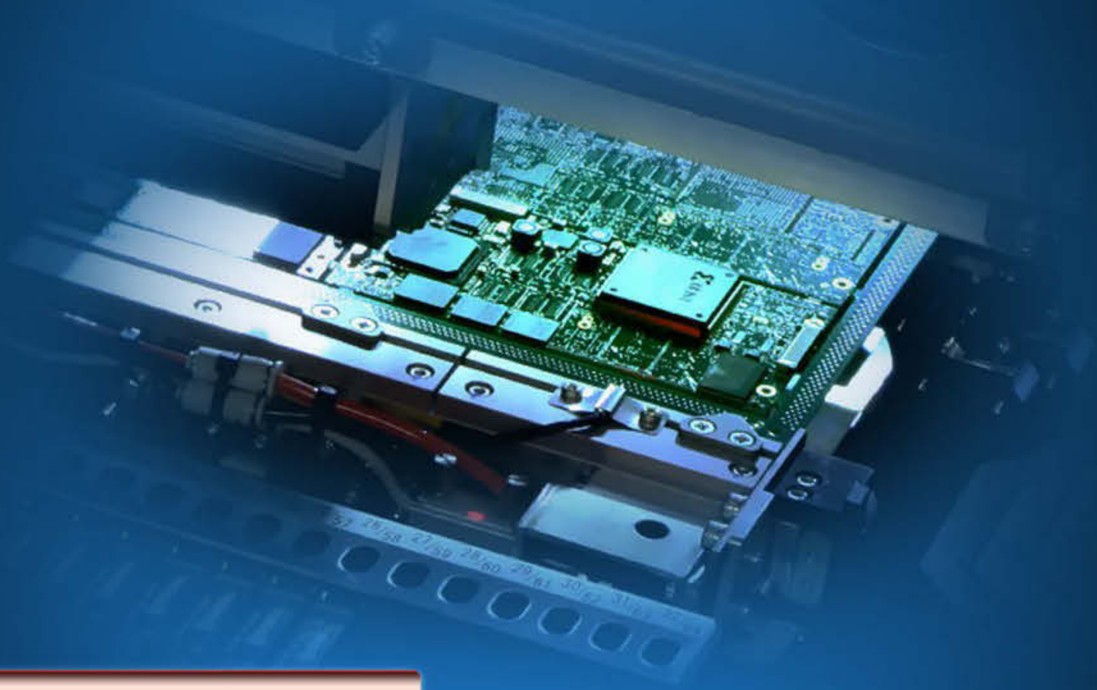

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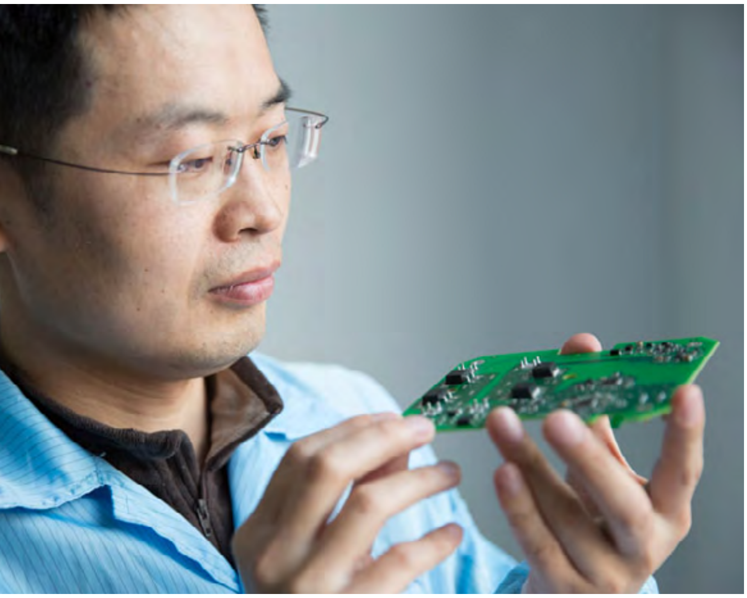
to talk to the people doing the work, seeing the problem. They may not know about the intricacies of the materials they use and the coating, the solder paste, etc., but they know stuff, they see stuff. As long as you can then interpret what they see and see what has changed or what material isn't appropriate, etc. They have the ability to tell us and do our job for us. We've just got to interpret that information and to some extent that's what we engineers do with data.

They take SPC data, AOI data, they interpret it and then they can solve problems. We're using information both verbal and data to solve a problem. As long as we continue to do that and just don't ignore people or ignore data, then we'll have a more robust process. Finally, taking that information and making sure that we don't have the same mistake again and again and again, which is another bugbear.

Las Marias: Right, I remember when I was in this EMS facility in the Philippines. The management is saying that they have to talk to the operators in the line because those are the people who are really seeing what's happening, and they're experiencing those troubles and those issues. Definitely, their inputs have to be considered as well when it comes to analyzing what went wrong or what improvements they need to make.

Willis: I love training people on the shop floor, the hands-on stuff, because they are more demanding than any engineer I've ever trained. Because they want to know how to do it, they want to know how to do it better, to make everybody else happy. If you can get that sort of reaction with people that's absolutely fabulous because they're there to do a job. They may not have the same skill sets as other people in the factory but they are in most instances very eager to learn.

If you can put the information in a nicely understandable package for people but it shows them, it doesn't just talk at them, because there are loads of people out there who can tell you what to do but they can't actually show you what to do. That's what they want because they'll see through you. If I went on to the floor and did something and said do this, do that, but I actually didn't know what I was talking about. That happens occasionally, but they would see through you. They would say that stuff won't go through that hole. That material won't flow like that. So as long as you



can then take the information they have which is a problem and pass it back as recommendations in a nice and timely manner then they're going to be happy.

Las Marias: Do you have something to add to that, Jason?

Keeping: I was just going to complement what both you and Bob were saying a second ago. That's the whole thing about continuous improvement. You need to give the feedback from the doers that they understand what the challenges are with the equipment or process they are doing. Then you have the leadership that's looking at when you go to APEX or the fall meetings. What's the new equipment and what are their capabilities? Is there something that is something new that now will help to address one of those issues that's been identified?

Then you start doing those evaluations so that you can look at what's the new equipment that's coming? Does it meet or does it not address those situations that you already know we have to make things work better? That's the best practice, not just by having continuous improvement, but by having communication with the right and appropriate people.

Las Marias: Do you have any final comments?

Willis: As a magazine and a group of magazines, you guys keep on doing what you're doing because I think you're very professional, and you have a very varied output. I've always been impressed when I've worked with your team before. You just keep on doing what you're doing , as Curtis Mayfield said all those years ago.

Las Marias: Thank you very much for that. Jason?

Keeping: I just second what Bob just said, and I just really appreciate and admire that you actually are talking to the doers and users like Bob and myself, real people in the industry and getting that ground level up review of actually how things are happening, and now writing about it. That's admirable, it's great and I like reading your articles.

Las Marias: Great, thank you very much for your kind words.

Willis: No problem.

Keeping: Thanks. SMT007

Editor's Note: All photos, except that of Bob Willis, are courtesy of Celestica Inc.

You may reach Bob Willis by clicking here.

MilAero Highlights

NASA Technology Managers Visit TopLine at Space Tech Expo ▶

Members of the NASA Technology Licensing and Commercialization Team visited the TopLine exhibit at the recent 2018 Space Tech Expo show in Pasadena, California, where they awarded a NASA lapel pin to TopLine CEO Martin Hart in appreciation of TopLine's efforts to develop a business model around PID (Particle Impact Damper) technology.

CDM Electronics Receives Raytheon Integrated Defense Systems' 4-Star Supplier Excellence Award ▶

CDM Electronics recently received Raytheon's Integrated Defense Systems (IDS) business' 4-Star Supplier Excellence Award for their performance throughout 2017.

MC Assembly Wins New Defense Logistics Agency Contract ▶

EMS firm MC Test Service Inc. (dba MC Assembly) has been awarded a new contract for the M1A2 Abrams main battle tank from the Defense Logistics Agency in Warren, Mich.

Season Group's US Operation Obtains AS9100D Certification ▶

Season Group recently obtained AS9100D certification for its US facility in San Antonio, Texas – to add to the AS9100D approval already in place for its facilities in the UK, Canada, and Malaysia.

HANZA Strengthens Production Capabilities in Sweden ▶

HANZA Holding AB has launched two new manufacturing technologies—heat treatment and non-destructive testing—to further strengthen its offerings at its manufacturing cluster in Sweden.

Sparton Teams with Raytheon on Next-Gen Mine Neutralization System ▶

Sparton Corp. will team with Raytheon to support the design, test, and deployment of the next generation Barracuda Mine Neutralization system.

Nortech Names Two New Board Members ▶

Nortech Systems Inc. has announced that Jay D. Miller and Dr. Steven Rosenstone were recently elected to its board of directors.

Libra Industries Awarded by Ohio Division of Safety and Hygiene ▶

Libra Industries has received a safety award from the Ohio Bureau of Workers' Compensation (BWC).

IEC Electronics Posts 49% Growth in Q2 FY2018 Revenues ▶

IEC Electronics Corp. has reported revenues of $31.8 million for the fiscal 2018 second quarter ended March 30, 2018, an increase of 49% as compared to revenues of $21.4 million for the second quarter of fiscal 2017.

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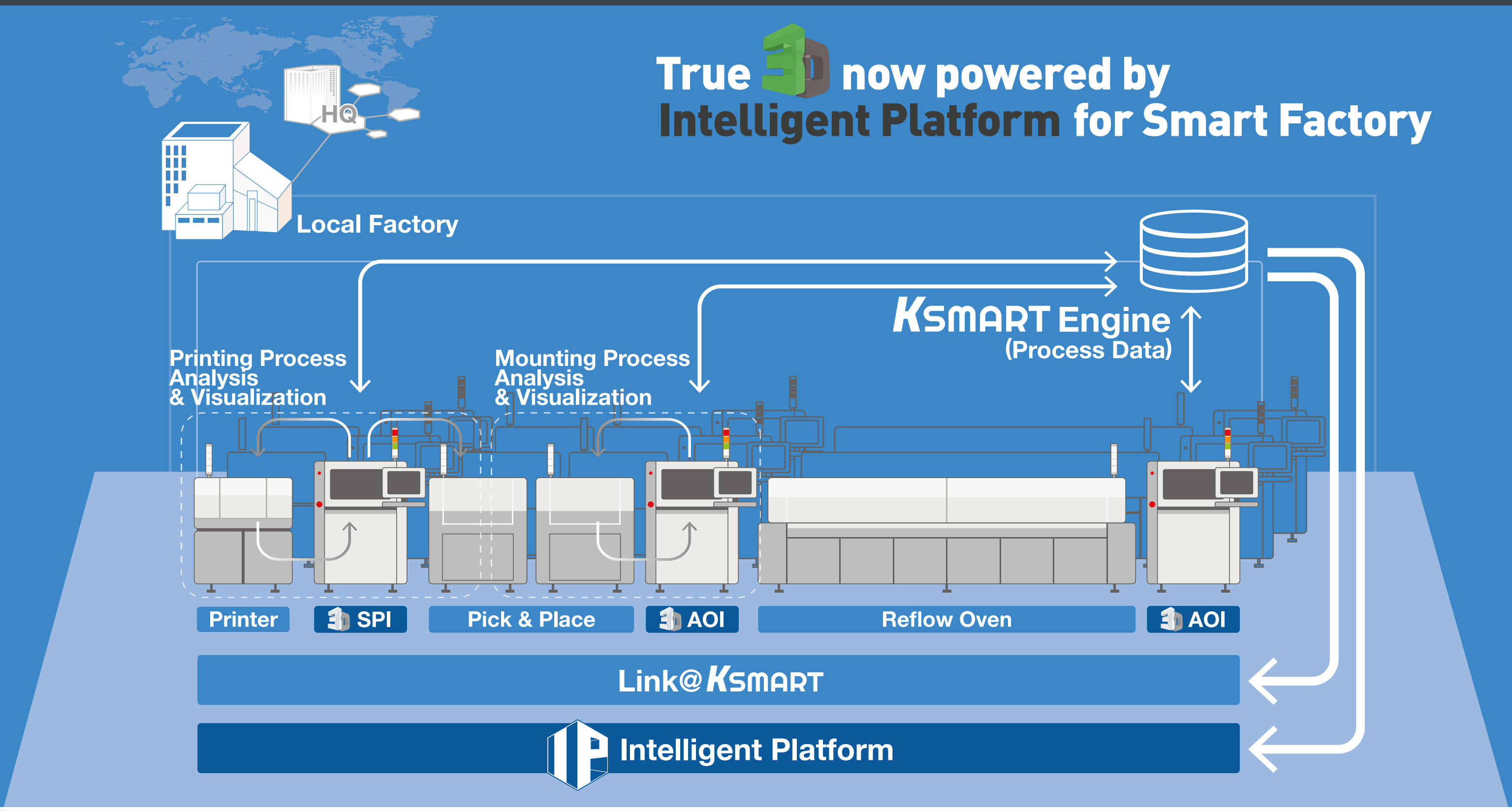

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Figure 1: Medical device assembly has always been one of many considerations in the product development cycle of today's products. But assembly has become increasingly challenging as devices grow more complex, functional and compact, and as they undergo frequent product refresh cycles.

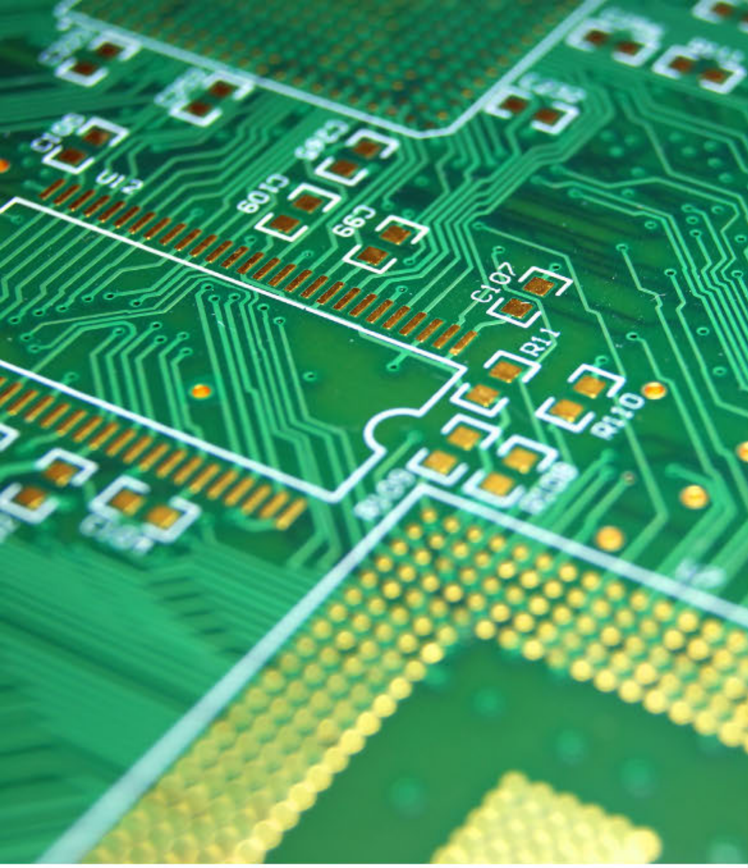
How DFA Converts Complexity into Freedom for Medical Device Development

Feature by Craig Stott, Ed Sermanoukian, and Girish Wable
NYPRO

The assembly of medical devices comprising electronic and mechanical components has always been one of many considerations in the product development cycle. But the assembly phase has become an increasing challenge as devices grow more complex, functional and compact, and as they undergo increasingly frequent product refresh cycles. The medical devices emerging today have evolved from purely mechanical systems into sophisticated electro-mechanical designs that are embedded in and driven by a rapidly growing connected digital health ecosystem. As a consequence, many now incorporate integrated sensing, power, processing, communication and analytics functions in ever-shrinking form-factors designed for optimal reliability, power efficiency and ease of use. Concurrent with this evolution, the various global reimbursement policies and regulatory approval processes for medical devices are also becoming more complex.

This growing complexity of medical devices is also unfolding in parallel with an increasingly competitive marketplace, which is putting pressure on device innovators to combine fundamental design for excellence rules, good manufacturing practices for supply chain and manufacturing operations, and innovative new materials and processes to deliver accretive value at rapid speeds and lowest cost.

Put simply, the design process is still driven by product requirements. By also considering the optimum path for assembly, however,



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manufacturers can achieve further benefits in the overall quality, reliability, time to market, cost and—most importantly—the efficacy of their medical device.

But what factors determine the best method of assembly? How, for example, do you choose between a manual, semi-automatic, fully automatic and flexible automation solution upfront when your device will go through rapid product refresh cycles?

One way to optimize both the design of a device and the efficiency of its assembly process is to employ design for X (DFX) review tools. Whether focused on manufacturability (DFM) or assembly (DFA), utilizing these design tools early in the product development process can anticipate and avoid many barriers to efficiency and performance, and achieve faster time to market.

A medical device designer, for example, may have a very clear vision of a product's end requirements. But they may have overlooked common issues that arise during the intermediate assembly phase, where there are often potential trade-offs to consider, such as the comparatively higher assembly and testing costs for a medical device that must reliably deliver over a million hours of service.

A design for assembly (DFA) approach anticipates these questions and prioritizes assembly methods and costs accordingly within the overall product development cycle. A typical DFA process might consider, for example, the percentage of parts standardized across different assemblies, part count consolidation and modularity, minimization of handling and cycle times, standardization of gripping methods and opportunities to reduce post assembly processes. The DFA process also seeks to minimize the time it takes to operationalize product assembly, and to ensure that supplier maturity will remain consistent over the period of development. Another important input of the DFA process is support for other DFX guidelines as part of continuous improvement. Ultimately, DFA should help to reduce throughput time, control assembly costs, enhance safety for operators, and ensure a design meets all specification, quality and reliability targets at an acceptable product cost.

Options Need Not Overwhelm

Depending on product requirements and design, assembly can be as simple as mechanically snapping components together or as complex as using functional integration like adhesives, welding or riveting.

Product managers also must often choose between manually assembling devices vs

Figure 2: The design and functionality of medical devices is not the only thing growing more complex. Various global reimbursement policies and regulatory approval processes are also putting more demands on how these devices are assembled.

employing semi-automatic or fully automatic options during the early design development stage.

Further complicating the selection process are the number of different assembly methods, which include:

1. Deformation methods based on press fit, heat staking, swaging, molded-in snap latches and retention features designed into mating parts
2. Mechanical fastening methods, encompassing the use of screws, bolts, rivets, pins, retention rings, springs or clips
3. Welding parts using ultrasonic, radio or high frequency, laser and spin tools
4. Soldering mechanical or electronics parts on a PCB
5. Bonding parts using pressure sensitive adhesives, epoxies, cyanoacrylates, polyurethanes or solvent cement materials. Bonding may also span employ processes, such a dispensing, curing, laminating, molding, coating and so on
6. Marking parts for component or assembly tracking, while not expressly involving assembly, may still eliminate, streamline or influence assembly processes. Marking encompasses surface treatments through flame, corona, plasma, solvent or ultrasonic washing, and may apply tools such as lasers, ink jet, bar coding, pin coding or adhesive labels
7. Testability or access to inline testing should be considered during design phase, testability should be considered to ensure that, at a certain assembly stage, the device has access points to test for pass/fail prior to proceeding to next station

The long list above still leaves open the question of whether the assembly method chosen should apply a manual or automated process. Manual assembly is best suited for high-complexity, low-volume assembly. Ideally, a complex assembly should be broken down into incremental assembly steps that can be handled by fixturing or automation to ensure manual assembly does not cause fatigue or errors.

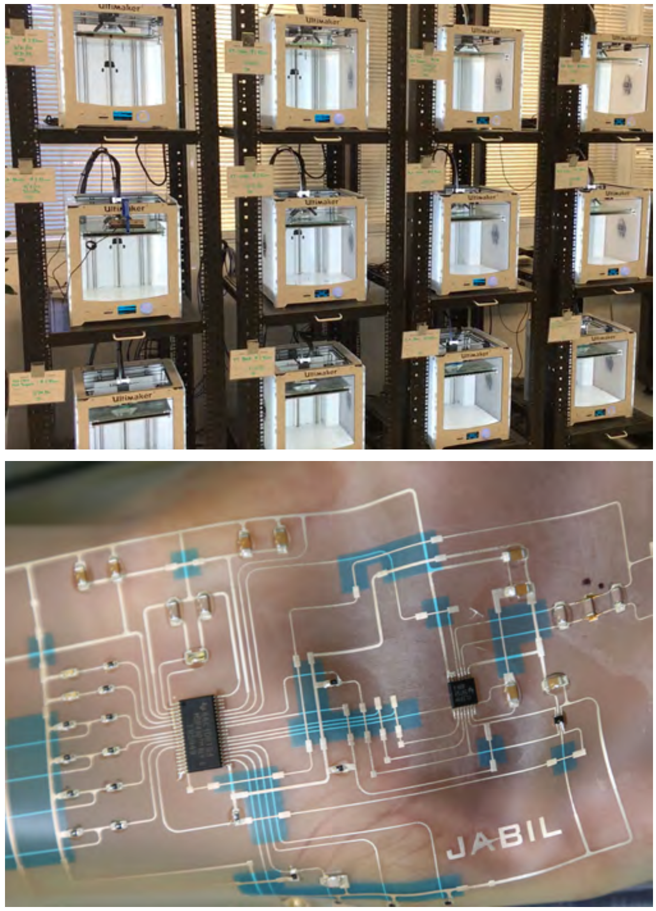


Figure 3: While traditional assembly techniques continue to dominate medical device assembly today, the emergence of additive manufacturing and printed electronics are helping manufacturers to deliver highly engineered and integrated products.

Automated and semi-automated processes are better suited for assembly applications demanding consistent repeatability, conformance to strict time requirements, or production volumes over a million devices per year. Flexible automation solutions based on a common standard platform where fixtures and tools can be reconfigured and adapted are favored for products that are customized for different markets or that go through frequent product refresh cycles. Additional automation benefits include reduced risk, scrap, errors and assembly time, as well as reduced operator hazard and fatigue. Automation also allows for data collection and analytics that help isolate issues more efficiently and resolved them more quickly to minimize downtown. The goal of DFA is to ensure the right decisions are made

Figure 4: Nypro's internal smart inhaler project used a fully-functional proof-of-concept to explore how such a connected device would work. Among the questions the team explored was how the features of its inhaler might help or hinder its mass production through a DFA process that involved brainstorming hundreds of design concepts and narrowing them down to approximately ten options offering the lowest risk and cost.

during the design phase to ensure higher quality, higher reliability, lower cost, and faster time to market

DFA in the Digital Age

While traditional assembly techniques continue to dominate medical device assembly today, the digital age has introduced innovative new options including additive manufacturing—or 3D printing—and printed electronics. Both emerging technologies are increasingly helping manufacturers to deliver highly engineered and integrated products, and both further underscore the importance of a DFA review.

Additive manufacturing can produce parts through a layer-by-layer printing process that eliminates the need for part-specific tooling, or the use of excess materials associated with traditional assembly processes such as machining or molding. As a digital manufacturing process, it allows manufacture of complex parts otherwise difficult or impossible through traditional manufacturing or assembly methods, as well as consolidation of components, streamlined introduction of new products and new possibilities for integrating embedded electronics. In short, it unlocks immense design freedoms.

Printed electronics is another additive process that focuses on fabrication of electronic devices, components and products. It applies novel materials to fabricate electronic structures by sequentially depositing layers of materials on top of each other. These structures can be created on a wide variety of substrates such as FR4, flexible polyamide, formable PET or PC, stretchable TPU, flexible glass and even textiles. It enables complex integration of functions using traditional processes like hybrid surface mount and die attach technology, lamination, forming and injection molding to deliver flexible and conformal form factors.

Able to deliver very complex electronic designs, these techniques are being integrated into smart and connected manufacturing concepts and combined with more traditional assembly processes such as surface mount soldering to improve upon solid manufacturing foundations. Smart manufacturing leverages data, network connectivity, business management platforms, machine sensors and flexible automation to accelerate the collection, visualization, communication, analytics and, ultimately the agility of manufacturing operations.

The digitalization of industry is relevant to the design process as much as the factory floor and has application in a medical device OEM's DFA review. The digital platforms utilized in manufacturing can leverage DFA data and potentially integrate real time feedback of manufacturing events to DfA violations. Such tools also provide a collaborative platform for product and manufacturing teams to work on design evolution in real time. They also enable the integration of artificial intelligence (AI) and machine learning systems to improve the performance of processes like solder paste inspection and optical inspection systems for cosmetic inspection of medical products. This area is ripe for innovation and offers options for eliminating issues of fatigue and perceptive variability associated with manual cosmetic inspection while escalating the value of manual intervention to a higher degree.

In summary, the wide variety of assembly methods can translate as greater freedom or more complexity for medical device designers. The sooner DFA analysis is performed during early design phase, the higher the chances that changes can be implemented with minimum impact. A device's design is not the only factor that guides selection of the optimum assembly method for individual components, and the earlier designers incorporate assembly in their product development plans the better able they are to lower capital expenditure, reduce risks, track quality through data and accelerate time to market. It will be exciting to see how the evolution and adoption of digitalization tools will help integrate this key step early on in the design stage. **SMT007**

Craig Stott is a principal automation engineer at Nypro, a Jabil Company.

Ed Sermanoukian is a technical business development manager at Nypro, a Jabil Company.

Girish Wable is a senior manager for strategic capabilities at Jabil.

The Michigan SMTA Expo & Tech Forum 2018: A Review

In May, I-Connect007 Technical Editor Happy Holden had the adventure of driving across Michigan to visit the SMTA Michigan Expo & Tech Forum. The event was a well-organized and attended tabletop expo and technical forum with over 75 exhibitors.

The Tech Forum took the shape of two timely and interesting talks. First, Gary Goldberg and Mike Goldberg of Promation presented on robotic soldering solutions. They discussed the global market trends in the world of robotic soldering automation, what constitutes as an ideal candidate for robotic soldering automation and how the technology can assist in better allocation of labor force and improve overall soldering quality and process stability. Gary proceeded to dispel misconceptions about robotic soldering and educate attendees to the latest and greatest technology being developed and the new increasing challenges for robotic soldering automation suppliers.

Next, Scott Schwartz of Stratasys discussed 3D printing, and how additive manufacturing has been revolutionizing the manufacturing industry and is constantly changing the way people design, manufacture and market their new and existing products.

Read the full article here.

Figure 1: (a) The Stratasys 3D printer; and (b) various 3D printed examples including different painted, colored or plated surfaces.

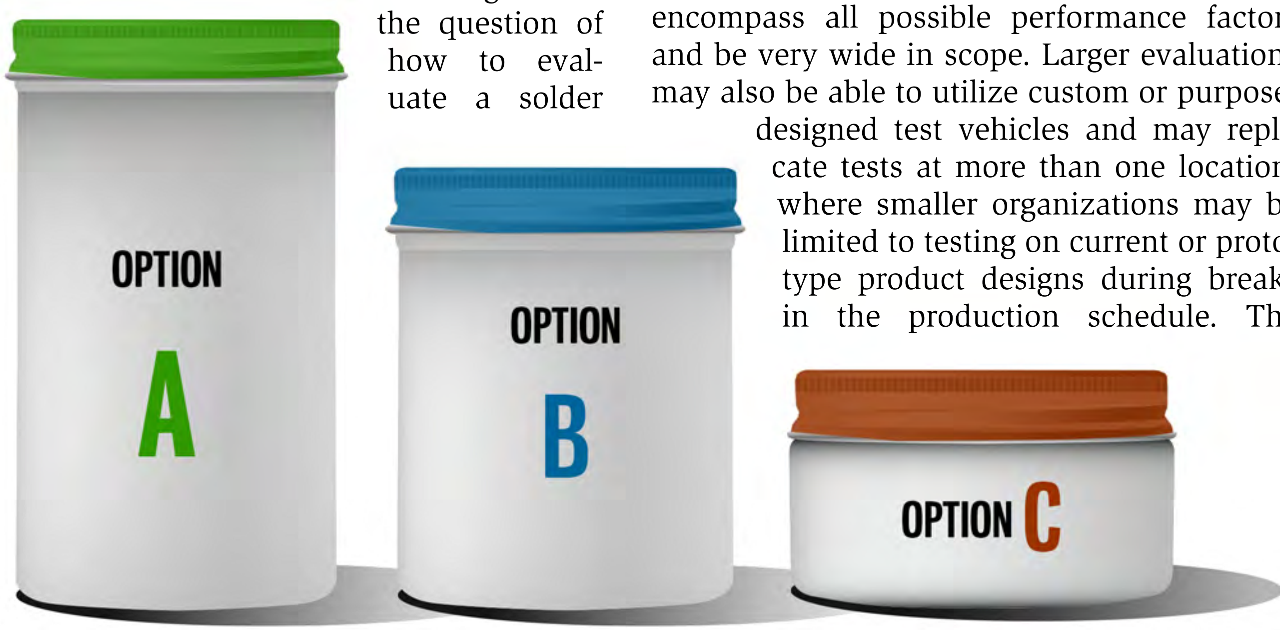
Strategies for Choosing Solder Paste for Successful Electronics Assembly

Feature by Jason Fullerton
ALPHA ASSEMBLY SOLUTIONS

As a technical support engineer for a solder manufacturer, I like to joke that nobody ever calls with easy questions. One common question that is received from current and prospective customers is, "How do I test and evaluate new solder pastes?"

Although that seems like it should be a straightforward question with an easy answer, this could not be further from the truth. The method of evaluation is of vital importance to an assembler who is looking to adopt a new solder paste because the resulting decision will impact factory operations for years to come. However, the best method of evaluation differs from one user to the next based on several factors. More simply put, the best answer that can be given to the question of how to evaluate a solder paste is also the last answer most people that ask want to hear: "It depends." Perhaps a better way to state the answer is, "What is important to you?"

So, if the best answer is different for everyone, how does one start to develop a test plan? A good start is to understand the level of resources that will be allocated to the evaluation, which is typically a function of organization size. If the evaluation is being performed by a small manufacturer with one SMT line and will be solely undertaken by a single engineer, then the focus should be limited to only the most important factors of solder paste product performance for that manufacturer. On the other hand, if the evaluation is being performed by a large multi-site (or even multinational) manufacturer and the testing is being performed by a team under the guidance of a subject matter expert, then the test plan should encompass all possible performance factors and be very wide in scope. Larger evaluations may also be able to utilize custom or purpose-designed test vehicles and may replicate tests at more than one location, where smaller organizations may be limited to testing on current or prototype product designs during breaks in the production schedule. The



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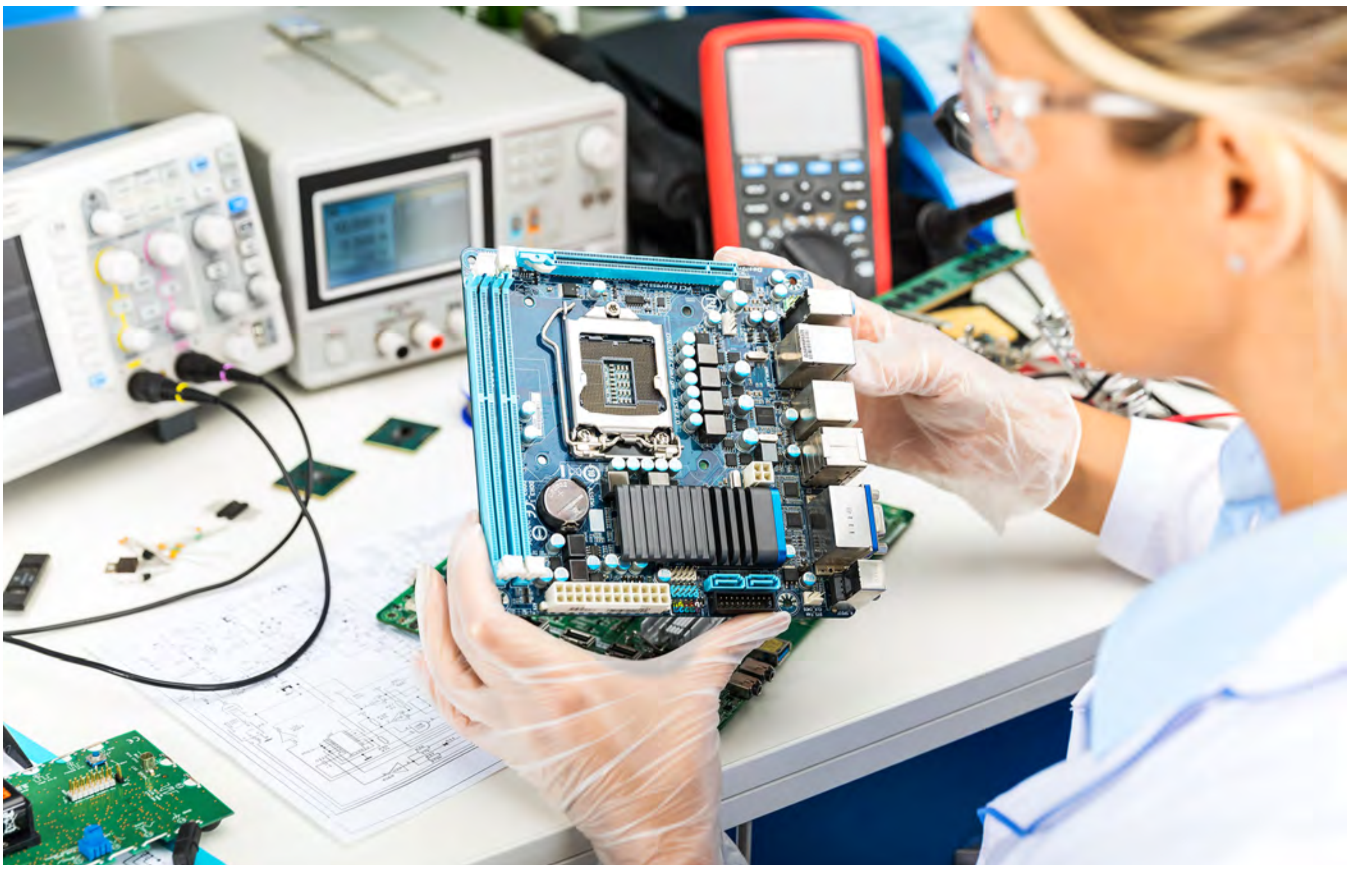
Now that there is an understanding about the general scope of the test plan, the next step is to determine the specific focus of the testing that will be performed. There are two key areas that any evaluation should investigate: quality and reliability.

Quality is defined by the American Society for Quality (ASQ) as "the characteristics of a product… that bear on its ability to satisfy stated or implied needs." In this case, the focus is on the key process output variables (KPOVs) from the solder print and reflow processes that are used to ensure the quality of the resulting printed circuit board assembly (PCBA). This varies by product function and design, so these key factors vary by assembler. The best place to find the KPOVs for any process is the process control plan, if one exists. These factors are the factors that are controlled for or inspected in the current process and represent the effort to make the product to specification.

The most obvious of the KPOVs come from solder paste inspection (SPI) systems: print volume, which is typically normalized as transfer efficiency (actual print volume divided by aperture theoretical volume, expressed as a percentage). Other SPI-based outputs include area coverage and height, which are best used as a supplement to volumetric measurements. It is important to analyze SPI data as a function of stencil area ratio for each aperture, as the distribution of transfer efficiencies will be a function of area ratio (A/R). Combining all the data together will result in an overall data distribution that is a combination of many different sub-distributions. For example, if testing a paste with a Type 4 powder size distribution (per IPC/ANSI-J-STD-005), the transfer efficiency for apertures with an A/R above 0.8 should be very close to 100% and have a distribution with low variation. The same paste, when tested on an aperture with an A/R of 0.50 will have a very different distribution with an expected lower transfer efficiency and higher variation. Combining the data from multiple A/R apertures can mask the



true level of performance, especially when too many data points come from locations where it is easy for all pastes to perform well.

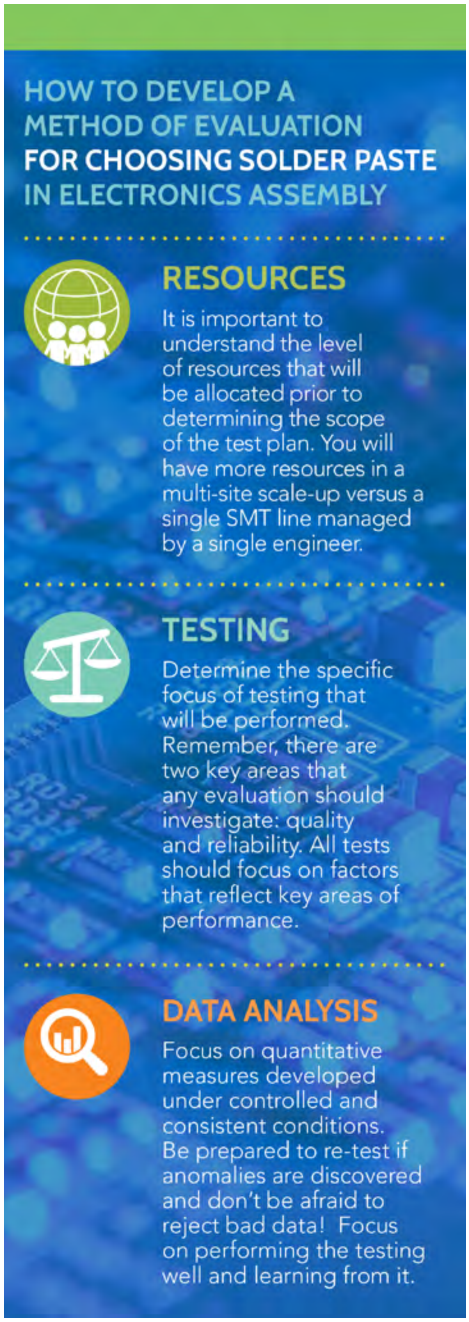
Other factors related to print performance that can also be included are slump performance, performance after pauses in production, and stencil life. That list is certainly not comprehensive and any factor that is important to an assembly process is a candidate for testing during an evaluation. Smaller evaluations may be able to rely on the testing performed by the manufacturer to standardized test methods such as hot and cold slump, where evaluations with higher resource allocation may desire to replicate these tests during evaluation. Larger evaluations can also develop unique tests or test vehicles to reflect specific issues encountered or unique needs of their application; the limits to evaluation test development are imagination and resource availability.

Reflow is another area where quality measures can be applied as an evaluation test. Voiding is probably the most obvious and relevant quality test that can be performed after reflow. There are also means to test the wetting and spread of a paste, resistance to graping, solder ball performance, and head in pillow and non-wet open defects. The focus during test development should be to identify the key outputs from reflow that are pertinent to the process, just as was done for print quality and with an eye towards resource limitations.

Reliability is the second major factor that any evaluation should include. Reliability is defined by ASQ as "The probability of a product's performing its intended function under stated conditions without failure for a given period of time." In the case of solder paste, there are two areas of focus: mechanical, which is driven by solder alloy, and electrochemical, which is driven by flux chemistry.

Reliability testing requires an understanding of the service environment of the end product, which is why the proper tests depend very heavily on the design of the assembly and how the customer uses it ("performing its intended function"), where the customer plans to use it ("under stated conditions"), and the length of the warranty or customer's expected product life ("without failure for a given period of time"). This is defined by the design function during product development, so these factors are generally easily determined by any organization performing both design and manufacturing. Contract manufacturers, on the other hand, rarely have visibility to these product factors and either need to choose representative tests or consult with their customers during development of any reliability test plan.

Unfortunately, reliability tests are neither inexpensive nor fast, so this is an area that can be tempting to cut out in smaller evaluations—but at the peril of those who choose to do so. Reliability factors are ones that cannot be easily observed at the time of manufacture, but manifest themselves as poor customer satisfaction over time, long after the decision to adopt a new material has been made. The Microsoft® Xbox 360 "Red Ring of Death" is an excellent example of a reliabil-



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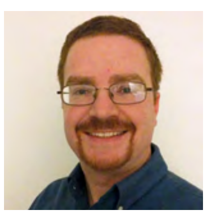
ity problem that wasn't detected during initial testing but became widespread in the service environment, demonstrating how expensive it can be if key reliability tests are not performed when appropriate.

Testing for mechanical performance is primarily driven by the alloy, so any manufacturer that desires to replace a SAC305 paste with another SAC305 paste can rely on past testing in most cases with certain market segments as possible exceptions (e.g., medical, aerospace, automotive). Examples of mechanical reliability tests include vibration, drop/shock, thermal cycling, and high-temperature endurance. Vibration and drop/shock test mechanical stress robustness, thermal cycling tests fatigue life, and high temperature endurance tests resistance to creep. The actual parameters for these tests, such as temperature, test duration, vibration amplitude, and drop height heavily depend on the product and its intended service environment.

Testing for electrochemical reliability is of key importance for no-clean processes. Electrochemical reliability testing requires the use of a temperature/humidity/bias (THB) test condition. At the material level, suppliers use various surface insulation resistance (SIR) tests to demonstrate that their material meets the minimum level of performance required by the specification. However, these tests all use one specific bias, design, and environmental condition set so they cannot replicate all possible design combinations. Therefore, testing on assemblies while powered and exposed to appropriate environmental conditions is critical to validating the suitability of any no-clean flux for use on an assembly.

Testing for potential electrochemical reliability defects is also important for processes that employ cleaning after soldering, but those processes require a focus on ensuring cleanliness after cleaning. Processes that employ cleaning can typically rely on extraction testing (e.g., resistance of solvent extract, ionograph, ion chromatography) on assemblies to demonstrate the effectiveness of the cleaning process. The THB testing described for no-clean assemblies can also be performed on cleaned assemblies as a means of assuring that the cleaning process results in reliable assemblies at the test limits used for extraction testing. The reader is cautioned that extraction testing on uncleaned no-clean materials, used alone and without correlation to parallel THB testing on assemblies, is not suitable as a reliability evaluation test.

Finally, any good test plan has a focus on quantitative measures developed under controlled and consistent conditions. If anomalies are observed in the data while it is being analyzed, the data should be considered suspect and an effort to determine the cause of the anomaly and eliminate it should be performed. This may also require performing re-testing in some cases as a good evaluation is one where special cause factors are not unfairly present on a subset of the pastes under test. Do not be afraid to reject bad data, even if that is an unpopular choice! You can follow good data where it leads you and expect successful use of the chosen solder paste for years to come. The focus should be on performing the testing well and collecting good data on the last attempt, rather than requiring that the test is done perfectly on the first and only attempt planned. **SMT007**



Jason Fullerton is a customer technical support engineer at Alpha Assembly Solutions.

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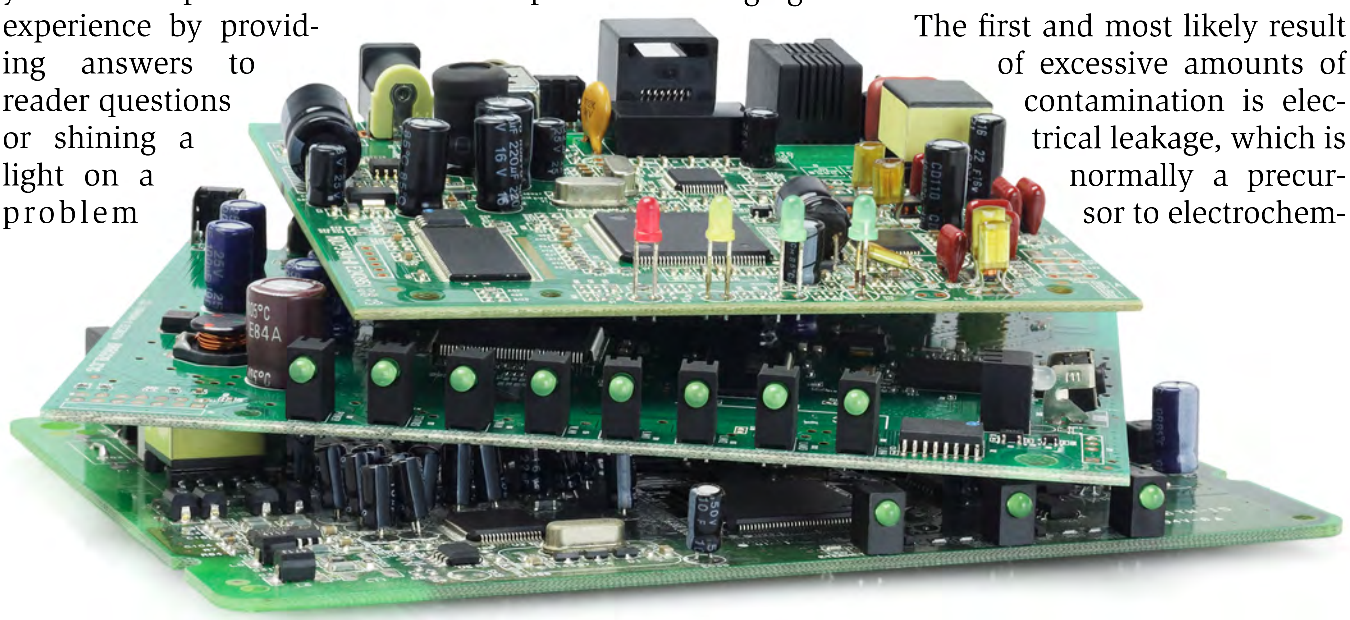
Contamination: The Enemy of Electronics

Quest for Reliability
by Eric Camden, FORESITE


Eric Camden

Welcome to the first installation of "Quest for Reliability." The goal behind this column is to use my experience at an independent laboratory for over 18 years to help readers understand PCBA reliability issues, and more importantly, prevent suspect conditions in the first place. The laboratory I work in has served every sector of the electronics industry, from oil and gas equipment designed to function miles below the surface of the earth, to aerospace companies and everywhere in between. Not every column will be filled with data, photos, and 8D reports, but they will take a more hands-on approach to the assembly process from the perspective of analytical testing. I hope this column gives you a sneak preview of some of that priceless experience by providing answers to reader questions or shining a light on a problem you didn't know you had until this point. I was once told, "Experience is something you receive right after you need it," and this certainly applies to PCBA manufacturing.

This first column will focus on the basics of why contamination is bad for your product. It seems like a simple enough topic, and it is, but the heart of the issue is how to determine what the contamination is and how it was introduced. After you identify these items, you are armed with the information necessary to optimize the process and eliminate the problem. When you look at the overall cleanliness of the product, you must remember that it's not only what your processing introduces, but also what every process has introduced. Processing steps include, but are certainly not limited to, the following: component manufacturing, PCB fabrication, assembly, and all the handling time in between point zero and the final packaging out the door.



The first and most likely result of excessive amounts of contamination is electrical leakage, which is normally a precursor to electrochem-

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ical migration (also known as dendrite growth). These are hard shorts and solid failures that won't necessarily leave. When looking at an electrical leakage path, three ingredients must be present: conductive residues, voltage differential, and available atmospheric moisture. If you can remove any one of these three pieces, the likelihood of experiencing issues is greatly reduced. In the real world, removing either of the last two ingredients is not a good plan to make money, so let's assume that power will be applied and the product will indeed be used in some type of atmosphere. Thus, the focus shifts to the level of cleanliness. This is the one thing that can be controlled and monitored before shipping product to the field. Let's start at the beginning and look at each processing step related to each material choice.

The base for most assemblies is a standard laminate printed circuit board. The old saying is, "Garbage in, garbage out." This is especially true when processing with a no-clean flux type because there is not a final wash process that can make up for the sins committed upstream, so if you start with a dirty PCB, it will surely get worse before the product is complete. When the topic of PCB cleanliness comes up, a traditional bulk ionic test might be required or supplied. However, without corresponding data from a more sensitive analytical test, such as ion chromatography or surface insulation resistance, the number may supply little more than a false sense of security.

Too many OEMs and CMs look to others to decide what is acceptable and simply want to check a box to show due diligence, but if we have learned anything from our time analyzing field failures, it's that each manufacturer needs to own their process to build in quality based on the use of a specific product. The main problem is there isn't a one-size-fits-all number to use because each product has its own set of variables, like voltage, spacing, metallization, and end-use environment. This has led to many companies seeing issues in the field on product that passed the industry accepted test. They don't know where to turn next, but I digress back to bare board manufacturing.

Many times, PCB fabrication suppliers cut costs by using less than ideal water quality for washing and rinsing the etch and plating residues. This could mean anything from local river water (not a joke, I have seen this) to tap water with unknown amounts of dissolved solids and ionic content. Tap, or river, water has an increased surface tension that can prevent effective rinsing of vias around 8 mil or less on bare boards. This will leave behind processing chemistries that easily facilitate electrical leakage and corrosion. Most often, the only testing performed to supply a certificate of compliance is dimensional information. While this is equally important to the cleanliness data, it only tells you half of the story when looking at incoming bare board quality.

Components go through similar processing steps as bare boards. Both have metallization over a base metal and cleaning steps that include harsh chemistries that can induce issues in the field. When large enough amounts of the plating chemistries are left on the metalized finish, corrosion can propagate without additional moisture or voltage. These two factors can expedite the corrosion but are certainly not required.

After the bare board and components are chosen, they are assembled together using harsh processes that include aggressive flux chemistries and soldering temperatures, sometimes over 250°C. This is the step that has the most influence on the quality of the final product. Active flux residues are chief among processing residues and come from a lot of individual soldering processes. When using water soluble fluxes, any residue left behind will be conductive and corrosive. It isn't as easy to determine the ionic activity level when using a no-clean flux. By design, no-clean flux residue is left behind and assumed to be near benign after thermal excursion, but that's not always the case. Throw in the heavily requested aqueous cleaning of no-clean flux and you have yet another contributor of contamination.

The thinking behind the request to clean is well intentioned, but without knowledge of how no-clean fluxes work, the request can prove detrimental to quality. The reason behind this is when the cleaning process isn't 100% effective, the protective outer shell is removed and material that was intended to be bound will instead be exposed and easily absorb moisture. Think of it as ripping off the bandage and leaving the wound exposed to the elements.

So far, the information I have given only scratches the surface when discussing process residues, and I haven't discussed testing options at all. There are lots of choices to be made when building a PCBA, and within each of those choices, there are a lot of ways to do it wrong. In the end, the idea behind this column is to learn from others' mistakes. It's a whole lot less expensive. **SMT007**

The Value of a Global Sourcing Partner

by Dan Thau
MILLENNIUM CIRCUITS LTD

In today's highly competitive environment, global sourcing is no longer a competitive strategy; it is a standard practice. Understanding what it takes to truly do this successfully separates the industry leaders from the pretenders.

When the "Asian shift" in PCBs really began to take hold a few decades ago, it began with Japan, which was soon replaced by Taiwan, which was finally replaced by China. As this dynamic continues, one thing is certain: This international sourcing evolution will continue. To stay in the game, companies need to develop a global sourcing strategy to remain relevant and sustainable.

The challenges of developing a robust domestic PCB supply chain is daunting enough but moving onto the international stage presents a whole new degree of difficulty that most companies are not equipped to manage. Typically, only the biggest companies have the resources to do this on their own. Identifying potential global suppliers, traveling to audit the suppliers, and the ongoing supplier management is not only cost prohibitive for smaller organizations, but they usually don't have the expertise to manage this in-house. This is where the value of selecting a global sourcing partner becomes crystal clear.

Read the full article here.

Essential Task Order Execution in Contract Manufacturing

Feature by Stephanie Weaver
ZENTECH MANUFACTURING

Proper task order execution is essential for accurate accountability and tracking of customer programs and schedules. In a Department of Defense (DoD) contracting environment, there are many flow-downs from the contracting officer to the contract manufacturer (CM) that must be implemented, tracked and executed successfully.

Many contract vehicles are issued as indefinite delivery indefinite quantity (IDIQ) contracts with delivery orders (DO) or task orders (TO) issued by the contracting officer on a periodic and as required basis to formally task the CM with releasing product builds for manufacturing and delivery against the contract requirements. The disciplines required to support the DoD contracting environment represent best practices and are equally applicable to the commercial sector when applied by a high-performing CM.

Below are some best practices to ensure task order execution success.

1. Establish one primary POC to communicate with the customer.

For example, task order management processes can be managed by a Program Manager. The PM will organize, schedule, and begin monitoring all phases of work described in the task order proposal. The PM will also prepare progress reports, conduct progress meetings, communicate with the customer and ensure that all deliverables are shipped on time.

2. Maintain a robust enterprise resource planning (ERP) system with an integrated material requirements planning (MRP) module for ordering and tracking project material requirements. This provides real-time orders-in-process tracking and coordinated design change and deviations.

3. Daily manufacturing meetings.

These meetings are comprised of the procurement, receiving/shipping/kitting, and manufacturing operations staff. These brief meetings are held to assure understanding of the day's planned tasks, and to promote effective planning, problem resolution, and risk mitigation.

4. Weekly reviews with all departments.

Manufacturing, program managers, executive administration, engineering, and purchas-

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ing conduct weekly reviews to ensure successful contract completion and collaboratively resolve issues that have come up during the week before.

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Su
10	WC-1	KIT/PREP	105.00	50.00	0.00	-0.01000	
20	WC-1A	AWAITING SHORT	105.00	0.00	0.00	-0.01000	
25	WC-1B	LABELS	105.00	0.50	0.06	-0.01000	
30	WC-2	KIT VERIFICATION	105.00	0.00	0.00	-0.01000	
40	WC-2A	KIT HOLD	105.00	0.00	0.00	-0.01000	
45	IC-FAI	FIRST ARTICLE	105.00	0.00	0.00	-0.01000	
50	WC-B	PCB BAKE	105.00	0.25	3.50	-0.01000	
55	PROCES	PROCESS MONITOR	105.00	0.00	0.00	-0.01000	
	PERFORM SPI AND LOG DATA PER SERNO FOR ALL BOARDS IN THE LOT						
60	WC-3	SMT	105.00	15.55	37.39	-0.01000	
70	WC-3A	SMT HOLD SHORT	105.00	0.00	0.00	-0.01000	
80	126B X-RAY	3D X-RAY	105.00	0.25	26.25	-0.01000	
90	WC-4	AOI	105.00	0.50	13.69	-0.01000	
100	WC-4A	AOI REWORK	105.00	0.00	6.17	-0.01000	
110	IC-5	SOLDER INSP	105.00	0.08	32.90	-0.01000	
120	WC-5	PROCESS EVAL CTR	105.00	0.00	6.17	-0.01000	
130	WC-ION	IONOGRAPH TEST	105.00	0.00	0.00	-0.01000	
140	WC-15	TEST	105.00	0.50	8.75	-0.01000	
	Flying probe testing						
150	WC-TS	TROUBLESHOOTING	105.00	0.00	0.00	-0.01000	
160	IC-15	TEST/REWORK INSP	105.00	0.08	3.50	-0.01000	
170	WC-15	TEST	105.00	0.50	8.75	-0.01000	
	Boundry scan testing						
180	WC-TS	TROUBLESHOOTING	105.00	0.00	0.00	-0.01000	
190	IC-15	TEST/REWORK INSP	105.00	0.08	3.50	-0.01000	
200	WC-11	BONDING	105.00	0.25	17.85	-0.01000	
210	IC-11	BOND INSP	105.00	0.08	6.72	-0.01000	
220	IC-FNL	FINAL INSP AUDIT	105.00	0.08	14.00	-0.01000	
225	WC-NPI	NEW PRODUCT	105.00	0.00	0.00	-0.01000	
	FAI is required						
230	WC-16	QA AUDIT/INL SRC	105.00	0.08	14.00	-0.01000	
240	WC-19	REC TO STOCK	105.00	0.00	0.18	-0.01000	
		Totals		68.78	203.38	-0.28	
		Totals per Unit		0.66	1.94	0.00	

Figure 1: Example of a production lot traveler.

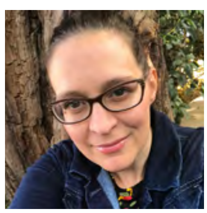
5. Meticulous parts ordering and receiving process.

The purchasing department orders all materials (components, hardware, PCBs, wire, sheet metal) listed on the BOM (bill of materials) for each job. When materials are received, they go through incoming inspection according to a counterfeit parts mitigation procedure, and part accuracy is verified against the customer BOM. Once correct, the parts are placed in a job kit box. Prior to its release to manufacturing, quality assurance (QA) audits all production kits for compliance to "machine ready" requirements, BOM completeness, and component integrity. Each job is serialized so that it can easily be tracked throughout the manufacturing process.

6. Create a production lot traveler (PLT) and assembly instructions (AI).

The PLT lists the operations required to fabricate/assemble/inspect/test each item. The AI is the actual instructions used to assemble the product. These are both reviewed by the production manager and quality assurance and approved for use. The production manager assigns the job to assembly personnel and they review the PLT and the AI. The item is then assembled in accordance with the PLT and AI and inspected by quality assurance at in-process and final inspection.

All of these checks and balances ensure that a contract can be completed on time, on budget and with zero defects. Each step in the process allows for adjustments or corrections to occur real time, instead of discovering them at the end of the build or worse, when it's already arrived at the end user. **SMT007**



Stephanie Weaver is a business development manager at Zentech Manufacturing.

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Supply Line Highlights

LPKF Sees Increasing Use of UV Lasers ▶

Julian Rose, product manager for the UV and stencil laser machines of LPKF, discusses with I-Connect007 the challenges in laser stencils and strategies and techniques to address them, and the increasing use of UV lasers.

Mycronic Acquires MRSI Systems ▶

Mycronic AB has acquired North Billerica, Massachusetts-based MRSI Systems LLC (MRSI) for about $40.7 million.

Xcerra to be Acquired by Cohu ▶

Xcerra has signed a definitive agreement to be acquired by Cohu Inc., a supplier of semiconductor test and inspection handlers, micro-electro mechanical system test modules, test contactors and thermal sub-systems, for a total consideration of $13.92 per share.

Zestron Opens Technical Center in Taiwan ▶

With the opening of their new technical center in Hsinchu, Taiwan, Zestron now owns a total of eight globally linked technical support facilities throughout the world.

Electrica Boosts Quality Standards with Mirtec MV-3 OMNI ▶

Electrica Ltd recently acquired MIRTEC's MV-3 OMNI 3D AOI system to help increase quality and productivity throughout all phases of their manufacturing process as the company engages with more customers in the high-reliability markets.

Indium Launches Mobile-Friendly Chinese Language Website ▶

Indium Corporation has launched a mobile-friendly version of its website specifically designed for the Chinese market.

RTW NEPCON China: Christian Koenen Stencil Technologies Ensure First Pass Yields ▶

At the recent NEPCON China 2018 event in Shanghai, Michael Zahn, development manager for Christian Koenen GmbH, explains how stencil technologies can improve the solder paste printing process and ensure first pass yields.

RTW IPC APEX EXPO: Inspection Technology Developments ▶

Brian D'Amico, president of Mirtec Corp., speaks about the challenges of miniaturization, increasing component density, and the shadowing of small components by taller ones, and how Mirtec has developed its inspection technology to ensure they remain at the leading edge.

RTW IPC APEX EXPO: Koh Young Discusses New Equipment and Data Challenges ▶

Joel Scutchfield, Americas Sales Manager for Koh Young, discusses the company's latest inspection equipment and some of the challenges of providing customers the data they need for the real achievement of smart factory realization.

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Cross-Functional Teams Drive Strong Focus on Risk Mitigation and Quality

Feature by Sandy Kolp
FIRSTRONIC

The term CFT (cross-functional team) is used widely in the EMS industry to define the program team that interfaces with each customer. Normally, that term translates to customer-focused team and is a small group comprised of a program manager, customer engineer and buyer/planner. Firstronic's management team felt customers needed the breadth of a traditional cross-functional team approach, defining their CFT model as a much larger group, which includes a tactically-focused program manager, a strategically-focused account director, a buyer, a product engineer, a process engineer, a test engineer, a quality engineer, a production supervisor or lead person, and a customer service representative focused on materials and scheduling. The goal was to create a team that was broad-based enough to govern all the necessary outputs associated with each customer. Many of the company's programs involve production in multiple regions of the world, so the division of labor among a program manager and an account director ensures an internal tactical focus via the program manager, while the account director focuses on strategic and commercial issues and has accountability for global program performance.

The power of this approach was evident in the company's transition to the latest revision of the automotive quality standard IATF 16949. The International Standards Organization (ISO) was previously the governing body for ISO/TS 16949, and the current IATF 16949:2016 revision passes that responsibility to the International Automotive Task Force (IATF). Under

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Figure 1: Firstronic's CFTs analyze both product and process metrics.

the new standard, there is greater focus on risk management and definition of stakeholders whose interests must be considered in those assessments.

Firstronic's facility in Juarez, Mexico, recently received its certification to the revised IATF standard, while its Grand Rapids, Michigan facility will be certified later this year. In implementation, the quality management team found the IATF revision required stronger identification of the scope of the quality management system and customer-specific requirements. A key goal of the implementation process was to integrate risk management analysis into the organization at all levels. This required process definition, analysis of the links with interested parties for each process, and identification of the associated risks.

One of the first steps was defining process owners and their responsibilities. Process owners included program management, quality engineering, purchasing, sales, customer service, production operators, quality inspectors, shipping, quality management, process engineers, product engineers and supervisors. This aligned well with the CFT team concept already in place since CFTs are catalysts in driving risk mitigation for customer and company, managing product launch, changing management and continuous improvement.

The training program for CFTs is rigorous and includes training on process failure mode effects and analysis (PFMEA); 8D problem solving; corrective and preventative action; statistical process control (SPC); control plans; change management; understanding IATF processes and procedures; advanced product quality planning (APQP); installation, process installation, process qualification and operational qualification; the purchased part approval process (PPAP); and control plans. Six Sigma Green Belt training will be added later in 2018. The goal is to ensure all team members have a strong foundation in the core tools necessary to carry out their defined responsibilities in managing project launch, corrective actions and continuous improvement activities.

Firstronic's Plex Online ERP system enhances each team's abilities to manage and mitigate

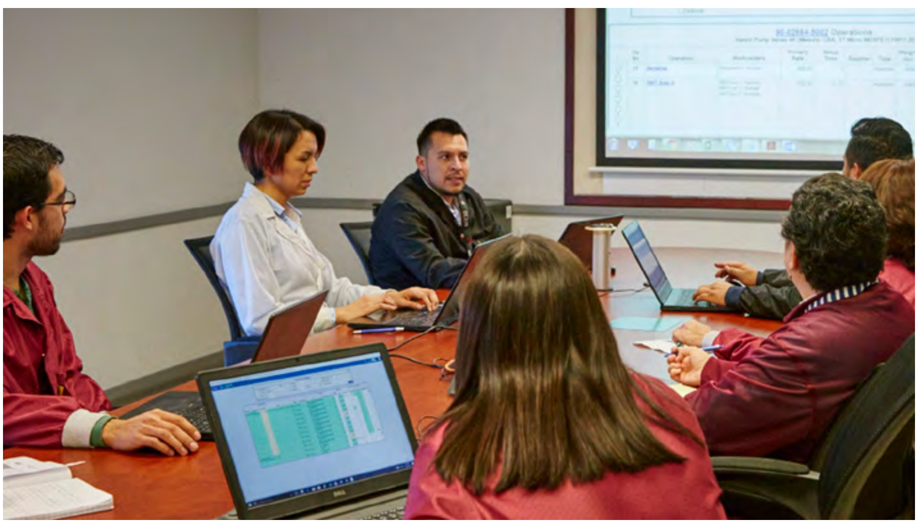


Figure 2: CFTs encompass a broad range of disciplines overseeing everything from project launch through continuous improvement activities.

risk. Plex allows searching for process and product risk. As part of every new customer transition, the team looks at the top ten product risks for that customer. Plex gives real-time visibility into all aspects of project activity to top management at all facets of the organization. Supply chain management and new product introduction (NPI) are two of the areas that have been most enhanced in terms of additional risk management tools.

Figure 3: Firstronic's projects often ramp in multiple facilities across the globe simultaneously.

The CFTs are key drivers of continuous improvement and a process one team identifies as necessary for a specific customer may be replicated with additional customers, if warranted. For example, as component availability issues started to become more frequent in one customer's products last year, the CFT recommended taking a more holistic approach to the problem. In the original model, component availability issues were addressed whenever the lead time on a specific component began to stretch out. The relevant team members would identify alternates and seek approval on those parts from the customer. As component shortages increased, this process was being used more frequently. The team did a complete bill of material (BOM) analysis for the products and gave the customer two to three alternates for every line item, even those without known availability issues. Documentation was provided for all recommendations along with descriptions of whether the alternate parts were drop-in replacements or needed a qualification process. The team then worked with the customer to get all feasible alternates added, managing qualification builds for end customer validation efforts. The process has now been replicated with all customers, particularly on new products.

CFTs are a front-line resource in ensuring that what is delivered to customers meets their requirements. They provide the rest of the organization clear focus on what resources are needed to support the customer. The broad-based nature of this team structure ensures that each customer has a complete set of subject matter experts focused on project execution and continuous improvement. The teams measure a number of metrics including process and specific product yield relative to key performance indicators (KPIs), customer and product line gross margin, forecast accuracy, revenue to project budget, on-time delivery performance, customer satisfaction, corrective actions and inventory turns. If issues arise in the metrics, the team analyses the root cause and recommends appropriate corrective action.

The result is a responsive, coordinated approach that mitigates risk, provides responsive solutions to any issues that develop in the project, and ensures lessons learned are propagated throughout the organization. **SMT007**

Sandy Kolp is the director of quality at Firstronic. She can be reached at skolp@firstronic.com.

Replating of Gold Fingers: Getting the Shine Back

Knocking Down the Bone Pile

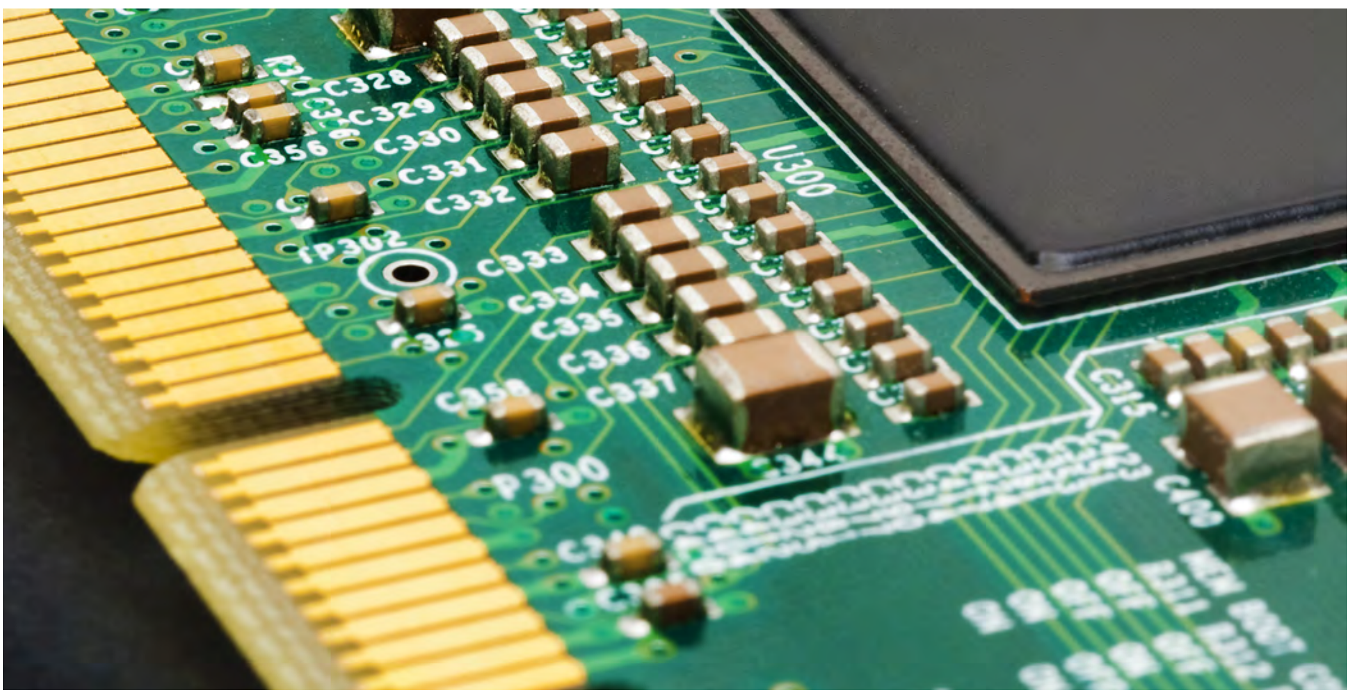
by **Bob Wettermann,** BEST INC.

There are several instances where the gold contacts on PCBs need to be replated. IPC A-610 discusses several of these cases. One of the more common defects is when solder "splashes" onto the contact during the wave or selective soldering process, thereby contaminating it. This requires that the operator strip away the solder, first by wicking off excess solder and then to a greater degree via mechanical and chemical stripping means. This is then followed by a replating of the contacts. Another defect is when "pitting" occurs in the contact area. This pitting is a result of a defective plating operation. Many times, this defect can be buffed out and then it can be replated. Other times, the contact area is scratched, which similarly requires the buffing out of the scratch followed by replating.

Gold replating of these contacts is a process that requires setup, special chemistry that requires advanced PCB repair tech skill, and the correct materials and training.

The operator skills required for gold contact replating are similar to those required for micro device rework and PCB repair. Patience, dexterity and the ability to improvise correctly if the standard process followed does not go as planned are all attributes of a PCB rework and repair technician. The most experienced and skilled techs are the right ones for being trained to perform PCB repair techniques such as gold finger replating.

Numerous materials are required for the proper repair of gold fingers per the industry standard IPC-7721 4.6.3, which in many cases can be had in a complete replating kit.



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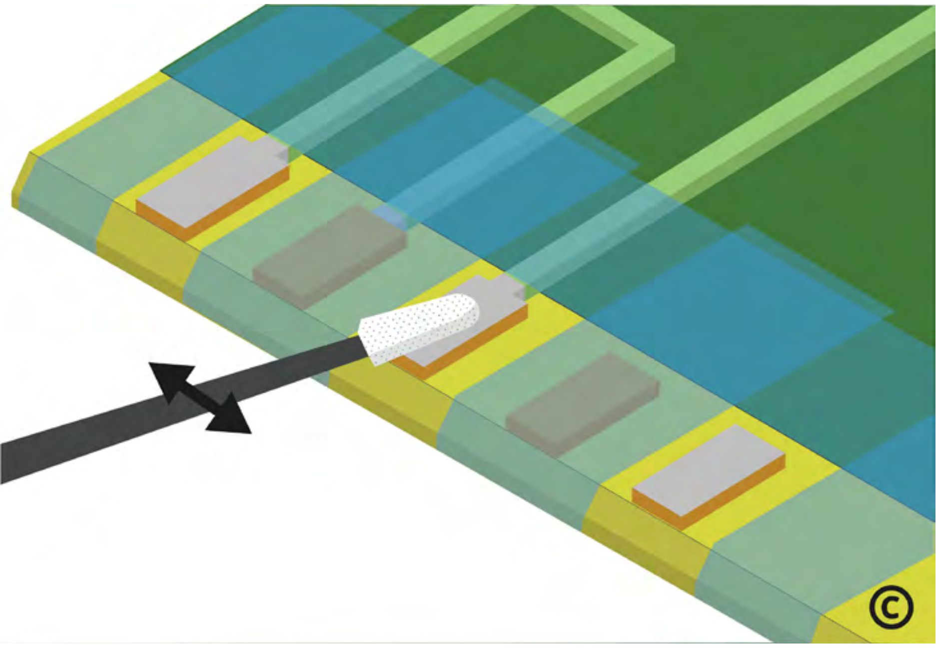

Figure 1: Stripping the remnants as part of preparing the contacts for replating.

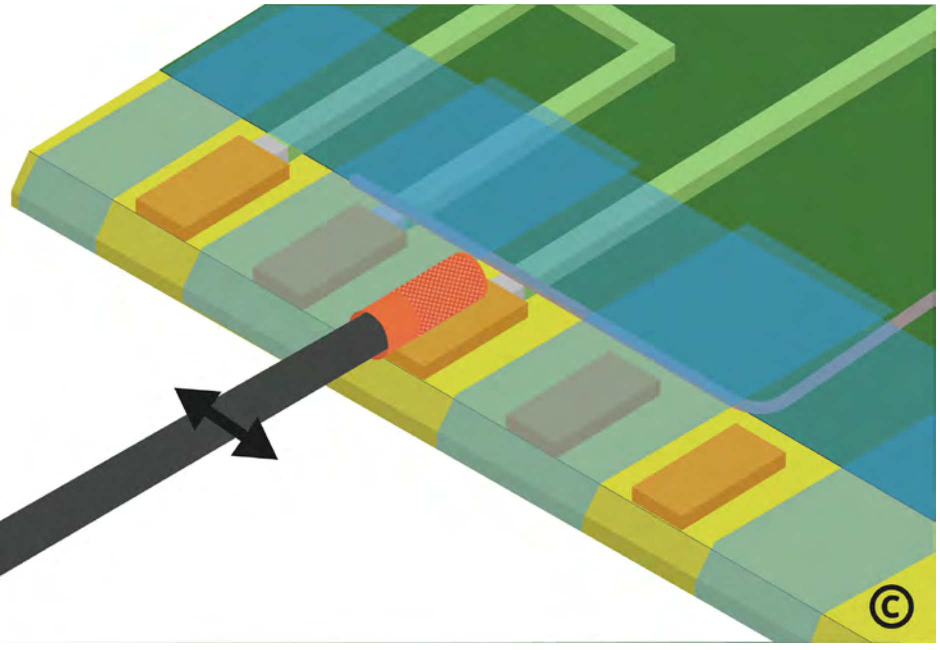

Figure 2: Replating the contact with gold solution.

Several solutions are required for the replating process, including the gold stripping and the nickel and the gold plating solutions. Applicator tips are put onto the end of the electrodes and come in a variety of sizes to accommodate the different gold finger geometries. A variable power supply will supply the current for the plating process. In addition, there are polishing materials including the polishing compound and water to rinse the remnant compound off the board. Finally, a grounding wire is used to form the bus to all the contacts requiring replating. As a warning the replating area should be properly ventilated and care must be taken for this process as the solutions are hazardous in nature.

There are numerous ways personnel can be trained in this PCB repair procedure. One method is via the IPC-7721 PCB repair program. This industry certification program can accommodate the training of this repair technique at the CIS level. Otherwise various training companies or gold replating suppliers can provide training in this repair technique.

The basic replating process is referenced in IPC-7721 4.6.3 or in the manufacturer's instructions as part of the gold replating kit. If the gold finger is severely damaged, a gold-plated circuit frame and the pad repair process as outlined in IPC-7721 procedure 4.6.1 or 4.6.2 can be utilized to replace the finger lieu of the replating process.

If you are outsourcing this as a service, inspect the replated area per the most recent IPC-A-610 guidelines (Revision G, Section 10.1.1). The bond strength of the plating material can also be measured using the peel tape test found in IPC TM-650. **SMT007**

Bob Wettermann is the principal of BEST Inc., a contract rework and repair facility in Chicago.

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DEMAND FORECASTING:

The Art of Knowing What You Need Before You Need It

Feature by Patty Rasmussen
EAST WEST MANUFACTURING

Of the many tests in global manufacturing, few are as challenging as mastering the art of demand forecasting. Even some of the best in business can make a mess of it. Forecasting is a skill born out of experience, intuition, and most of all, knowledge. But what do you need to know when you're creating an accurate demand forecast? What data is needed? Are there tools you can use? Where do you start?

Let's start by defining a demand forecast. The forecast is a document that plans and controls inventory. It's used to order material or product from the supplier to the customer, typically making stops along the way at the factory and warehouse. The forecast is built by the manufacturer customer service representative (CSR) taking a customer's historical sales data and projected sales data and figuring out how much product the customer needs in stock, how much product needs to be in the warehouse, how much product needs to be in production at any given time.

While the customer's input is important, the CSR's own data is vital. They look at how much the customer has ordered in the past and don't just take the customer's word for it.

Here's a hypothetical example:

Smart Company says it uses 500 PCBAs each month. Armed with that information and knowing that the manufacturer needs to hold components worth three months of production, Smart Company's purchasing team stocks 1,500 diodes and resistors in the warehouse. There's just one problem. Smart Company overestimated their usage. They only consume 200 PCBAs a month. The manufacturer only needed to stock components for 600 PCBAs in the warehouse, but now they have additional inventory for 900 PCBAs.

Not a great feeling.

But the inverse is just as bad. In fact, shortages might be even worse because it's more difficult and expensive to get product to the customer on short notice. Raise your hand if you've had one or more electronic component on backorder for months on end in the past 18 months. There's good news. Overages and

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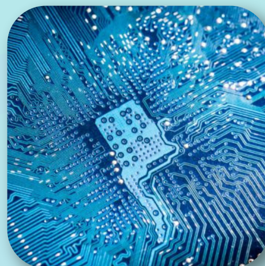

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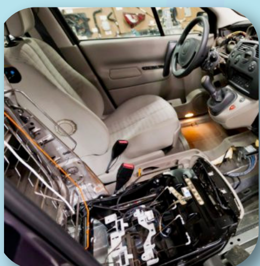

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shortages can be remedied, or at least mitigated, by building accurate forecasts.

10 Tips for Accurate Forecasting

1. Ask your CSR what they need from you. Make sure to get the information to them when they need it.

2. Better data means a better forecast. To get an accurate picture of your business, look at 12 months of sales data. This will give you the best idea of what you need to order and when you need it.

3. Tell your CSR of anything out of the ordinary on the horizon. If your product was just profiled in an industry publication and you anticipate a spike in sales or if you just lost a major customer, both will affect your forecast.

4. An accurate forecast is always better than a timely forecast. What do we mean? It's better to have a correct forecast made once a month than an incorrect forecast made once a week.

5. Take heed of events that can affect the forecast. Holidays are on the calendar; everyone knows they are coming, but year after year people make the mistake of not preparing for them. Talk to your CSR and find out how early you should be ordering for Chinese New Year, Tet or any other holiday that could disrupt the flow of your products.

6. Know the lead time for your product and keep it in mind when creating your forecast.

7. If you lack experience in forecasting hire someone who has it. Work with suppliers with experience in overseas shipping.

8. Ask questions. You're not going to be an expert at forecasting to begin with, but you can learn. Your CSR will be happy to help; there are webinars and tutorials galore. Become a student of the art of forecasting.

9. Stay vigilant! Forecasts are living documents and are easily affected by outside forces. Whether bottlenecks at the ports after the holidays, labor, or bad weather, you have to build recovery time into your forecast.

10. Schedule a regular "audit" of your account. Make sure your records and data are up-to-date. Put the upcoming holidays and suggested 'order by' dates on the calendar for next year (even if it's just in pencil). Has anything changed that needs to be communicated to your CSR?

Randy Strang, vice president of Global Program Management at UPS, spent the majority of his career designing and implementing global supply chain strategies. He knows a thing or two about forecasting and several years ago suggested manufacturers ask the

following questions to improve their forecast accuracy. It would be worth asking these questions of yourself/your supplier:

- How consistent is your demand?
- What are the factors that influence the variable, or variables being forecast?
- What level of supply chain visibility do you have?
- How reliable are your modes of transport?
- Do you have access to multiple modes of transport?

If you're not using forecasting tools/software, there are plenty out there and all come with salespeople eager to tell you about them. We aren't going to make suggestions of specific brands or types of software to use other than to say, don't overbuy for your needs. Probably the best way to start looking for forecasting software is to ask people you know in your industry what they use, what they would recommend and what they like or don't like about it.

Finally, we suggest that it is wise to remember that surprises are fun when you're six years old but not when you're engaged in overseas manufacturing or when you're waiting on a long-delayed electronic component. "The only guarantee in forecasting is that everything will not go exactly as planned," Strang wrote. In our experience that's true. The best thing a customer can do is to plan for every contingency, whether it seems likely or not. If you've got a good supplier, they'll have your back. **SMT007**

Patty Rasmussen is a content creator at East West Manufacturing.

Twisted Meta-molecules as They Really Are

Physicists at the University of Bath have devised a new and highly sensitive method to truly test the chirality of a material, eliminating the risk of false positives from competing effects.

Chiral molecules exist in different forms; even when they are made of the same atoms, those atoms can be arranged differently, twisting one way or another. This crucial difference can affect the properties of the molecules and has applications in fields such as telecommunications and nanorobotics, among others.

However, because of the nanoscopic nature of many of these molecules and materials, it can be difficult for scientists to be certain they are working with chiral molecules of a particular twist (known as "handedness"), as some tests can produce false positives.

The University of Bath team, working with colleagues at the Max Planck Institute for Intelligent Systems in Germany, demonstrated a method to separate the chirality of a substance from sources of false positives by using the way light interacts with artificial molecules that were made of tiny gold helices.

Dr Ventsislav Valev, Royal Society Research Fellow/Reader, Department of Physics, Centre for Photonics and Photonic Materials, Condensed Matter Physics CDT, led the research, while Joel Collins, PhD Researcher, conducted the experiment.

The research is published in the journal ACS Nano.

Electronics Industry News and Market Highlights

NB-IoT Device Shipments Will Reach 613.2 Million Units in 2023 ▶

According to a new research report from IoT analyst firm Berg Insight, global shipments of NB-IoT devices will grow at a CAGR of 41.8% from 106.9 million units in 2018 to reach 613.2 million units in 2023.

IDC Expects APEJ AR/VR Spending to Reach $11B in 2018 ▶

Asia/Pacific (excluding Japan) spending on augmented reality and virtual reality (AR/VR) is forecast to reach $11.1 billion in 2018, an increase of more than 100% from $4.6 billion the previous year.

Top 10 Semiconductor Foundries Worldwide for 1H18 ▶

TrendForce forecasts lower revenue growth for global foundries in 1H18 than in 1H17, with the total revenue reaching about $29.06 billion, a year-on-year growth of 7.7%.

On-Board Magnetic Sensor Market Worth $1.9B by 2023 ▶

The overall on-board magnetic sensor market is estimated to be worth $1.26 billion in 2018 and expected to reach $1.89 billion by 2023, growing at a CAGR of 8.4%, according to a new market research report by MarketsandMarkets.

Global NAND Flash Revenue Dropped by 3% QoQ in 1Q18 Due to Seasonal Influence ▶

The seasonal headwinds in the first quarter of 2018 has resulted in downward corrections of global NAND flash prices, according to the latest analysis by DRAMeXchange, a division of TrendForce.

US Defense Military Satellite Sector Fueled by Heightened Funding against Escalating Cyber Warfare ▶

Modernization strategies along with counter and offensive space initiatives create significant growth opportunities that could take the market past $30 billion by 2023, finds Frost & Sullivan.

North American Semiconductor Equipment Industry Posts April 2018 Billings ▶

North America-based manufacturers of semiconductor equipment posted $2.69 billion in billings worldwide in April 2018 (three-month average basis), according to the April Equipment Market Data Subscription Billings Report published by SEMI.

APEJ ICT Spending Including New Tech Expected to Exceed $1.5T in 2021 ▶

Spending for the Asia/Pacific (excluding Japan) information and communications technology market, including on new technologies, will reach $1.5 trillion in 2021, according to the latest IDC Worldwide Black Book: 3rd Platform Edition.

Rise of Connected Cars and AI Prompt Automotive Manufacturers to Partner with Software Vendors ▶

With an anticipated global connected vehicles of more than 200 million by 2025, automotive OEMs are looking to seize a competitive advantage by offering space-age customer experience.

IPC E-TEXTILES 2018

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How do you merge smart fabrics with smart engineering? Does your company have e-textiles or stretchable technologies on its roadmap? How do you take a product from concept to commercialization? Electronics trade association IPC has scheduled an industry-developed event to answer these and many more questions about e-textiles.

IPC E-Textiles 2018 is a one-day technical and business education workshop on e-textiles that will bring together innovators, technologists and engineers to collaborate on solutions, identify partners and identify solutions to propel growth for the e-textiles market.

Topics will deal with all aspects of e-textile development, including:

- E-textile wearables for consumers, sports, medical, military and safety markets
- Bringing the IoT to textiles
- How to develop an e-textiles business model
- How to collaborate with the supply chain to get the end-product you envision
- Materials and components that make up e-textiles and how to select the right ones for your

Visit www.ipc.org/E-Textiles-2018 for seminar updates and to register today.

IPC E-TEXTILES COMMITTEE MEETING

In addition to the technical education and networking on **September 13, IPC E-Textiles 2018** will also be host to an open-forum **IPC E-Textiles Committee Meeting on September 12.** Plan to arrive a day early to meet with others from your field to brainstorm standards and test methods needs and learn how to influence industry standards being developed by the IPC E-Textiles Committee.

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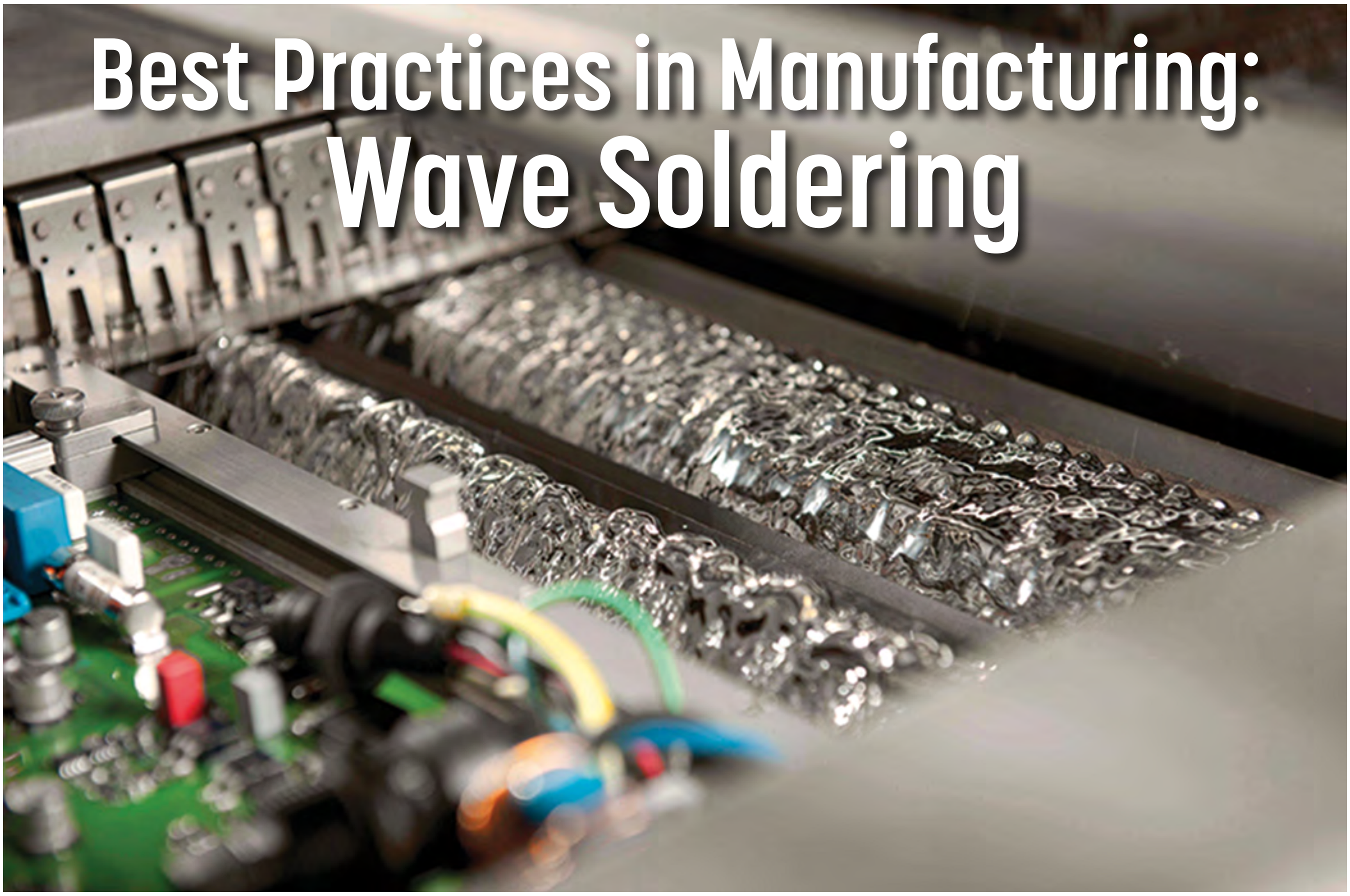

Best Practices in Manufacturing: Wave Soldering

Feature by Brian Morrison
VEXOS CORP.

Over the years, best practices have evolved and will continue to evolve with the changing environments, company needs and challenges and what may work for one company may not necessarily be best for another. A common area sometimes overlooked versus surface mount is wave solder, which can commonly introduce significant touch up and rework if not appropriately managed.

The following recommendations are based on experiences and best practices and is not intended to be considered hard and fast rules, but rather guidelines—your situation will dictate which practices work best for your company.

This article will be focusing on common wave defects and best practices to both address, predict and proactively prevent these issues from reoccurring. Contributing elements such as component selection/ considerations, design, tooling and process will be discussed.

By far the most common wave defect is bridging, which is the unwanted formation of solder between conductors. Defect contributors include component, design, tooling and process.

Solder Bridging

Component Considerations

Lead length: Specification of component lead length in the design versus the PCB thickness provides the respective protrusion of the lead into the solder during this process. Ensuring the lead length is neither too short (i.e., solder cannot reach the pin to achieve capacitary action) or too long (i.e., provides a pathway for webbing from one pin to the adjacent) can prorogate bridging for the assembly.

Best practice when specifying the component lead length is to ensure the lead length is long enough to provide the necessary heat transfer for proper wicking to provide sufficient barrel fill while neither exceeding the maximum protrusion specified as per IPC-A-610. A good rule of thumb is the length should not

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be longer than the distance between the two adjacent annular rings. By ensuring this is met, the probability of webbing is significantly reduced as surface tension will draw the solder to the nearest copper area. In cases where the lead length is too long, component prep and lead trimming are recommended to provide the desired length.

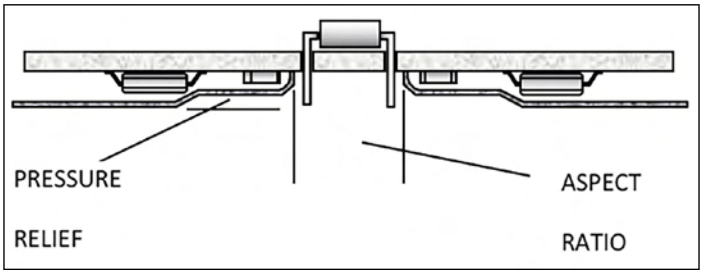

Figure 1: Bottom side surface mount component heights can drive thicker pallet requirements and further impact the ability of the solder to flow in and out of the pocket.

Other considerations related to the components themselves can be PCB contamination, component contamination, oxidation or solder mask issues.

Design Considerations

Component orientation: Particularly relevant to larger pin count connectors with at least two or more rows where orientation of the connector parallel to the wave can result in significant bridging occurrences.

Best practice is to ensure larger pin count connectors are orientated perpendicular to the wave to minimize the number of exposed trailing end pins of the connector where bridging is likely to occur. This is especially true for fine pitch. In situations where orientation cannot be accommodated, other methods such as solder thieves (effectively non-functional pads or copper features which are placed on the trailing edge to pull the solder away from the last lead to prevent bridging) can be designed either into the board or onto the selective wave pallet to minimize bridging.

Tooling Considerations

Some best practices in selective solder pallet design include proper PCB orientation in the selective wave pallet. It is recommended to angle the board between 15–30° to help mitigate the bridging to a few pins by ensuring only a handful of pins end up as trailing pins. This is especially helpful where larger pin connectors are designed parallel to the wave direction.

Sufficiently large wave openings and solder flow channels on the bottom of the wave pallet provides sufficient solder flow and flux application, preventing pooling or areas where solder is trapped resulting in bridging. Generally, constraints such as minimum clearance from the outside edge of the annular ring to a surface mount pad drive the opening size. Recommendation is 0.100” for this distance for proper design.

Bottom side surface mount component heights can drive thicker pallet requirements and further impact the ability of the solder to flow in and out of the pocket. The aspect ratio relates to the solder opening length/width versus the vertical travel required for the solder to reach the bottom of the PCB. The minimum ratio is 1:1 for leaded solder but increases to 1:3 for lead-free solder. That is, if the length/width is 0.150”, then the maximum vertical dimension is 0.150” for leaded solder. Violating this aspect ratio will obstruct proper flow and increase the chance of wave related defects.

Additionally, orientating the board on selective wave pallet at 15° degrees can help mitigate the bridging to a few pins. Typically, a hybrid solution of the above techniques provides the optimal solution.

Process Considerations

Selecting the right flux for the application as well as the appropriate thermal profile can have a significant impact on the formation of solder bridging, and selecting an appropriate flux for the thermal mass and heating profile required can have a significant impact on overall yield.

Generally, a higher solid content is more robust at higher temperatures and water-based fluxes do not perform as well at higher temperatures and better suited for lower thermal boards. Ensuring the pre-heat temperature and dwell time for your board is appropriate for your flux can mean the difference between a good and bad result. Burning off the flux prior to wave can result in bridging.

Lifted Components

Another common defect is components lifted after wave, which is more predominant on smaller components such as axial or radial components—but just as common on connectors and other components—which are lifted during contact with the wave and are soldered in placement. The most common practice to address is through component lead pre-forming and/or pallet hold downs.

Component Considerations

Ensuring components such as axial and radial components are properly prepped can avoid most lifting situations. Lead forming or clinching of the leads, which mechanically hold the components in place, are by far the most common. Common with bridging, leads that are too long can also exaggerate lifting, which acts as a lever to push the component out of position.

Tooling Considerations

Other components such as connectors which cannot easily be retained in place require additional hold downs, which can be in the form of glue or over-clamps as part of the selective solder.

When considering over-arms for clamping, the additional thermal mass introduced by these features must be considered in the profile and may potentially require a different flux for better performance.

Process Considerations

Wave height and the use of lambda versus laminar flow can also contribute to increased occurrences of component lifting. Ensuring wave heights are set to no more than 50% of the PCB thickness relative to the pallet and the use of turbulent flows should be minimized.

Other considerations include conveyor vibration, angle, etc.

Insufficient Solder

Another most common wave defect is insufficient solder and can be categorized as incomplete barrel fill or incomplete circumferential wetting.

Related, but typically more related to contamination of the solder, board or component, is de-wetting or non-wetting. For the purpose of this review, we will assume the components are in good condition prior to processing. Best practices to prevent introduction of these types of defects include a well-established incoming inspection process combined with solder dip testing as per IPC-TM-650 for suspect contaminated or oxidized components.

Design Considerations

Common design considerations are direct connection of plated through holes to large copper planes which act as a heat sink during wave soldering. To address this, best practice is to provide thermal relief in these areas to allow proper flow during soldering. Thermal

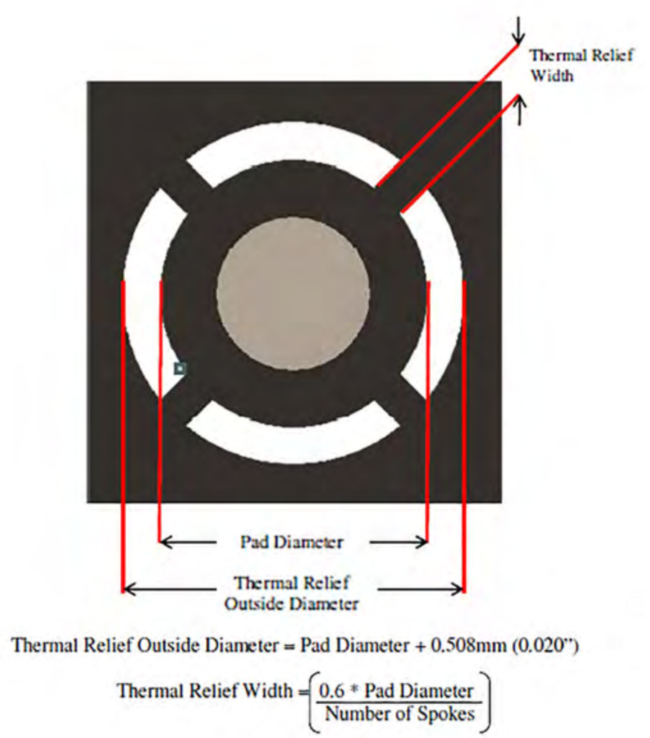

Figure 2: The direct connection of plated through-holes to large copper planes acts as a heat sink during wave soldering. The best practice is to provide thermal relief in these areas to allow proper flow during soldering.

spokes provide isolation and can significant increase the probability of a good joint.

Other considerations include component lead diameter to plated through hole diameter ratio mismatches. A plated through hole that is either too large or too small vs. the lead can equally result in insufficiencies. A recommended aspect ratio is typically 0.6 larger than the component lead will provide good results.

Process Considerations

Generally, this comes down to heat transfer or insufficient flux as either can have an equally significant impact on solder fill. Lack of flux penetration or presence due to profiles which are too hot are the most common root causes.

Products such as Fluxometer, which use acid paper and specially designed PCBs with regular spaced plated through holes, can be used to ensure the appropriate amount of flux and penetration (i.e., pressure) is applied for optimal use.

Regular or monthly reviews including levchecks or wave riders can also provide an indication of the wave levelness, temperature profile and overall oven performance and is recommended to ensure process drift related to the equipment is not a contributor to defects.

Figure 3: A Fluxometer can be used to ensure the appropriate amount of flux and penetration is applied for optimal use.

Solder Voids

Solder voids or out-gassing (blow holes and pin holes) occurs when a solder joint has a small hole that penetrates the surface of the solder connection. This is typically due to moisture entrapment that during the soldering process out gasses from the joint.

Process Considerations

Like components, PCBs are also moisture sensitive, however, they are commonly not treated in the same manner as moisture sensitive components. As a general rule, all PCBs should be considered MSL 3 and be managed as any other moisture-sensitive device.

Best practice is to ensure PCBs are sealed and only opened just prior to use. Extended periods between thermal cycle operations like surface mount reflow and wave should be considered when reviewing exposure time. If a board is not soldered within 72 hours after the previous thermal cycle operation, it should be baked to remove excessive moisture in accordance with J-STD-033 or kept in a dry cabinet with a relative humidity $<5\%$ to minimize the risk of such occurrences.

Solder Balls

Solder balls and spatter defects are generally where a small sphere of solder adheres to the laminate, resist or conductor after wave soldering. There are typically three types, random, non-random and splash back, which are all typically process related.

Process Considerations

For random solder balls, these are the easiest to address and are typically a result of an excessive flux prior to wave, uneven wave height. If you hear a “sizzle” while the board is going over the wave solder it is a good indication that the pre-heat is either too low or the flux application is too high or the wave temperature is set too high.

Non-random solder balls which appear in the same location or trailing pin are most commonly due to insufficient flux or pre-heats are too high.

Splash back is most commonly due to the wave height being too high or excessive turbulence in the wave. About 95% of applications, if designed appropriately, can be soldered with laminar flow only and is recommended to help avoid occurrences.

Best practice is to utilize tools such as the Fluxometer and WaveRIDER to check for parallelism and proper flux optimization to minimize such occurrences.

Figure 4: Vexos Production Lines.

Tooling Considerations

Areas of entrapment in the wave pallet can also contribute to solder balls. Reviewing pallet designs for solder flow to ensure there is sufficient flow channels or vents to allow outgassing during soldering can help minimize the occurrences of solder balls and spatter.

Icicles, Flags and Excessive Solder

Icicles and flags (horns) and excessive solder occur when a PCB passing through a soldering process either collects too much solder or develops an undesirable protrusion of solder from the joint. The most common contributor is process.

Process Considerations

By far, the most common reason is the wave solder pot temperature is too low or there is insufficient dwell on the solder pot. Best practice of 3–5 seconds of dwell is recommended for a proper joint formation. Tools such as oven-riders can provide an indication of solder pot temperature drift. It is always recommended to measure the solder pot temperature regularly to ensure proper temperature. Wave solder pot temperature readings from the machine do not always translate to actual and must be monitored.

Defect prevention is best performed through applying best practices through formalized design reviews and implementing process controls around key wave parameters such as solder pot temperature, pre-heat, dwell, parallelism and flux optimization.

Activities such as design for manufacturing (DFM) or design for assembly (DFA) can save significant time in applying design rules to ensure PCB design considerations, thermal requirements, manufacturing compatibility and related contributors are identified early in the design cycle where changes can be implemented at a fraction of the cost.

It is important to align with strategic manufacturing partners early on to provide relevant design feedback on all aspects on the design as the design decisions made early on can affect the long-term viability and cost of the product for the total lifecycle. **SMT007**

Brian Morrison, VP of Engineering for Vexos, is directly responsible for process, test, and development, focused on new customer and new product introduction. Morrison aided in the development of the company's corporate technology roadmap, systems and processes, value engineering, environmental management, and manufacturing initiatives to drive lower cost, flexible solutions, and manufacturing innovation.

Use of Lean Manufacturing Principles Enhances Quality and Productivity

Article by Mike Baldwin
SPECTRUM ASSEMBLY INC.

Regional EMS providers typically provide greater flexibility and responsiveness to their box build customers via use of work-cell-based batch assembly processes. Production volumes are fairly low, so the creation of dedicated continuous flow paced assembly lines is rare. However, we often see larger footprints and more complex projects with higher volumes.

Our cable, harness and PCBA manufacturing capabilities attract companies with products requiring complex subassemblies. As a result, it utilizes both work-cell-based and continuous-flow-line assembly in its box build assembly area.

One recent project example illustrates why this flexibility is important. The customer develops sports therapy devices used by trainers and professional sports teams. They had a next-generation product that increased functionality and, as a result, became mechanically much more complex. They needed a contract manufacturer capable of assisting them with development of mechanical manufacturing process instructions in addition to manufacturing the product. SAI helped develop the manufacturing process instructions as part of its new product introduction (NPI) services. The customer's documentation for wire and cable assemblies, electronic assemblies, mechanical assemblies and cosmetics requirements is transmitted to the Aegis system and used to create visual work instructions that are utilized by the production team.

This project included cables, harnesses, PCBAs, electro-mechanical, fluidic, air and water subassemblies as well as chassis, sheet metal, plastics and hardware components. Routing the tubing in a limited chassis space was a challenge. Our team used the same process templates used in developing efficient wire and harness routing to route the fluidic, air and water lines. Trial builds were performed to ensure correct air pres-

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Figure 1: The units involve complex electromechanical assemblies.

sure and water flow, and once nailed down, a tubing cut list was developed to make sure that all tubing was cut to appropriate lengths for the preferred routing. The customer validated the process. While computer modeling of this type of routing seems efficient, a routing that looks great on the computer screen can turn out to be an inefficient order of operations on the production line based on the obstacles that operators encounter during the assembly process. Having a combination of computer modelling and hands-on trial builds meant nothing was missed and that the order of operations was fully optimized.

Initially, the project was planned as a batch build process in several dedicated work cells, however, the volumes quickly outgrew that model. Our team utilized Lean manufacturing principles to redesign production flow from a cellular manufacturing process to a single conveyorized production line that integrated subassemblies with final assembly. Lean manufacturing principles were a core part of this redesign effort.

In the original process, cables, harnesses, PCBAs and subassemblies were assembled separately and pulled from stock. Final units were assembled sequentially by a pair of production operators.

The redesigned line has seven "feeder" work cells where production operators build electronic subassemblies consisting of multiple PCBAs, an onboard computer and associated harnesses; the fluidics; heating elements, cooling elements and additional subassemblies. In total, there are over 800 line items, seven custom PCBAs and 37 custom cables. At each station, operators add their subassembly to the base unit as it moves down the conveyor line. Programming, serialization, functional test, burn-in and crating are located at the end of the line. As part of this process, a 17-page device history record (DHR) is created and electronically filed for future use.

The continuous flow line minimizes materials and product transport by stocking materials and subassemblies near point-of-use. Oper-

Figure 2: Operators add subassemblies as the units progress down a conveyorized line.

ators are now cross-trained to assemble both a subassembly component and their portion of the final assembly which enhances efficiency and better balances workflow on the project. Workflow is visual so production status and engineering change order (ECO) impact is easily verifiable. "Wait state" work-in-process (WIP) is minimized since production operators are preparing the material they need for the day's production quota. Basic cable/harness assembly and PCBAs are built in their respective production areas and stocked on the line at the point of use.

Figure 3: Preassembled subassemblies are pulled from feeder stations adjacent to the line.

From an employee quality-of-life and safety standpoint there are significant benefits to this approach. The finished product is large and heavy. The conveyor arrangement places the product to be worked on at a level where a standing production operator can easily complete assembly tasks with no need to kneel or bend. A pneumatic platform at the end of the line lowers finished units for wheeled transport to test so no operator lifting is required. The shifting between subassembly build and final assembly build enlarges each operator's areas of responsibility, adding variety to the assigned tasks performed. The standing assembly element enables operators to have a wider range of motion during their daily activities which helps minimize the risk of repetitive stress injuries.

While regional EMS providers are often thought of as companies primarily focused on PCBA assembly and cellular box builds, this example illustrates that an EMS provider skilled in mechanical assembly can easily shift to higher-volume work. The redesigned line help simplify a complex electromechanical assembly project and facilitated daily shipments on a project with growing volumes. **SMT007**

Mike Baldwin is vice president at Spectrum Assembly Inc. He can be reached at mikeb@saicorp.com.

AXI 4.0 in a Smart Factory Environment

Article by Matthias Müller and Andreas Türk
GOEPEL ELECTRONIC GMBH

If you want to be well placed for the future, you have to live a digital and connected life. This applies to virtually all sectors in the professional environment—but it plays a central role in the electronics industry. Without a doubt, the machinery is an important resource. They must be able to think for themselves and optimize processes. Yet, the people behind the machines are important, too. Without them, the factories would fall silent. That is why it is vital that the systems are easy to operate. The use of an automated X-ray inspection (AXI) system by Goepel electronic in Limtronik GmbH's smart factory demonstrates how intelligent machines can be operated in a simple way to make good use of this interconnectedness.

Based in Limburg, Germany, EMS firm Limtronik has a total of three SMD assembly lines, one of which is a prototyping line. The two main lines are each equipped with powerful pick-and-place machines capable of handling up to 10 feeder modules, and a solder paste inspection (SPI) and an automatic optical inspection (AOI) machines. As is typical among EMS providers, product diversity varies greatly: individual assemblies and prototypes are every bit as much a part of day-to-day business as high-volume production runs. The complexity of the assemblies is likewise vastly different.

Assembly Testing and QA Using Automated X-ray

Outstanding quality is vital to be able to survive the fierce competition between contract manufacturers. Customers from the security technology, automotive, and medical technology sectors require almost 100% test coverage. Thanks to inspection systems in the assembly line and electrical testing in the test bay (in-circuit test, function test and JTAG/boundary scan), Limtronik is well positioned. To check the quality of solder joints especially in BGAs and QFNs, Limtronik installed Goepel electronic's X Line · 3D Series 100 AXI system in 2010 to achieve full-surface 3D X-ray imaging within the cycle time. After several years

Figure 1: Verification station for viewing detected faults: BGA with void.

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Figure 2: Andreas Türk from Goepel electronic (left) with Limtronik AOI/AXI technician Manuel Sehr at the X Line · 3D.

in continuous operation, it was replaced by a new model from the Series 300.

Face-to-face assemblies are common, that is, assemblies in which BGAs are populated congruently on both the top and underside. Reliable quality control is only possible with 3D X-ray. Superpositions of BGA and SMD capacitors, likewise, pose a major challenge since they have a high density and complicate the evaluation of the X-ray images. However, layered reconstruction of the solder joints offered by X Line · 3D provides reliable analysis in a very short time. A 4-way panel of an assembly with multiple BGAs and a size of 216 mm x 164 mm, for example, needs on average just 26 seconds for the full 3D X-ray inspection.

Software and Smart Operation

It is not just adhering to cycle times that is important in production. A low level of programming complexity and simple operation are valued in particular by contract manufacturers with frequently changing assemblies with varying lot sizes. Thanks to a complete offline programming concept with the programming software PILOT AXI, test programs can be created and optimized remotely. A test procedure wizard guides the user through creating the program, from importing the CAD data to debugging the test program, helping with quick parametrisation of the test functions. The machine software PILOT Inspect makes handling the X-ray system even more convenient for the operator. The app-style touch-control operating concept clearly displays the most important information and allows even

Figure 3: Monitoring and controlling the X-ray system from a tablet.

new operators to get to grips with the system quickly, thanks to integrated information messages, images and videos. The inspection system can also be controlled and operated remotely using a tablet.

"Even at my workstation in the office, I have all the information that I would have otherwise only had at the machine itself," says Manuel Sehr, AOI/AXI technician at Limtronik. "I can monitor and control the system, thus enabling me to avoid downtimes and diagnose problems remotely. I can even chat with the system operator from the comfort of my office. It may sound trivial, but it helps clear up questions and problems quickly."

Limtronik Smart Factory

The terms "Industry 4.0" and smart factory have been circulating for many years in the electronics industry. There is barely a company in existence that doesn't adorn itself with these particular feathers. Although it is only applied to machine labelling in some areas, Limtronik is one of the most cutting-edge EMS companies in the country and is a pioneer of smart manufacturing.

Concrete implementation is based on the interconnectedness of all elements and on creating added value by leveraging useful information from a large data pool. Gerd Ohl, director at Limtronik, refers to it as "turning big data into smart data". It's not simply a matter of collecting data—it's more about data mining. This is understood to mean using statistical methods to obtain empirical relationships from a database—recognizing patterns and trends and prompting machines to take action as required. A project such as this is implemented in collaboration with partners from research and IT fields. All the data—from the assembly process or the manufacturing execution system (MES), for example—is relayed to the project partners, validated and verified. The X Line·3D also plays a role in this. In addition to the full results of an inspection, machine statuses and operating times are also relayed. Among other things, this is intended to enable better planning and integration of future maintenance cycles.

Figure 4: Gerd Ohl, director at Limtronik GmbH.

At Limtronik, the aim of data mining is to discover factors that influence subsequent manufacturing results. For example, relationships can be established between solder paste application, the soldering process and any defects subsequently found in the X-ray system so that the processes can then be adapted.

In the long term, this leads to a reduction both in the pseudo-fault rate and in the number of rejects due to faulty components. In addition to this vertical connectivity in the smart factory, Ohl also sees horizontal connectivity as a forward-looking concept. "We want to involve our customers more and provide them with more data upstream," he says.

In concrete terms, preprocessed data can be used to accelerate bid processes and the customer can be provided with a virtual simulation of the assembly in advance, for example. New product lines should be up and running even faster, thanks to much more efficient creation of test programs. This is also supported by the AXI system from Goepel electronic, since it supports the latest ODB++ standard and loads panels which are already fully preconfigured into the programming software.

"In the EMS environment, the customer rents the factory for a period of time. Data mining allows operating costs to be reduced, and these cost savings are in turn passed on to the customer," explains Ohl.

Summary and Conclusion

Together, Goepel electronic and Limtronik are pushing two approaches: an inspection system must be highly efficient when it comes to fault detection and speed, and at the same time must be easy to operate. On the other hand, it must also be integrated in the connected factory like a link in a chain. 3D X-ray technology allows production-line inspection to be carried out within the cycle time. Collecting data is simply not enough if you want to implement Industry 4.0 wisely, which is why Limtronik relies on data mining and works in close cooperation with its partners to offer its customers an advantage through smart manufacturing. **SMT007**

Matthias Müller is a public relations manager at Goepel electronic GmbH.

Andreas Türk is the AXI product manager at Goepel electronic GmbH.

Raising the Capability Ceiling: SMTA Upper Midwest Chapter Expo

by Tara Dunn
OMNI PCB

An energetic and engaged crowd filled the venue at the recent SMTA Upper Midwest Chapter Expo. The event, held in Minneapolis, Minnesota, hosted 57 exhibiting companies and had over 100 pre-registered attendees. Attendees were invited to three technical presentations and a fabulous lunch, and they had the opportunity to interact with exhibitors to learn about new programs and technologies. The underlying theme for the technical presentations was "Raising the Capability Ceiling!"

The event kicked off with a presentation by Bill Cardoso from Creative Electron, who discussed iPhones and the technological advances displayed by Apple's latest model. Ray Rattey of TEXMAC/Takaya gave the second presentation, "Flying Probe Test as Part of the Total Test Strategy."

Will Slade, 3D-MID, Laboratories of Multiple Dimensions, marked the final speaker of the day. He spoke about the emerging market of molded interconnect device (3D-MID) technology and how it allows manufacturers to insert circuitry directly onto injection-molded plastic parts.

With all these exciting new technologies and applications for PCB and PCA manufacturing, it is easy to see that our industry will continue to become more challenging as time goes on.

In addition to the technical presentations, exhibitors from all areas of the industry discussed new technologies, product offerings, and capabilities. There were plenty of opportunities for networking and catching up with colleagues throughout the day. A new addition to the fun of the raffle prizes was the bingo game. Attendees had the opportunity to visit with exhibitors and complete bingo cards for a chance to win raffle prizes. With over 20 raffle prizes donated by exhibitors, there were many happy winners!

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Full Material Declarations:
Removing Barriers to Environmental Data Reporting

Article by Roger L. Franz
TE CONNECTIVITY

Full material declaration of product content in electronics and other industries continues to be a challenge for both suppliers and customers alike. For suppliers, managing substance-level data for all the materials in products is not usually a part of normal business operations; rather, it is an added burden and therefore cost to doing business. Customers, from mid-supply chain enterprises to OEMs, must have processes and systems to request, manage, and utilize the data to ensure compliance with worldwide substance regulations. These issues call out for easy-to-use software solution to aid reporting.

The IPC-1752A Materials Declaration Management Standard, which is aligned with IPC-1751A Generic Requirements for Declaration Process Management, is widely used for environmental reporting today. The standard specifies an XML (extensible markup language) schema for mandatory and required data, including support for Class D FMDs (full material declarations) for homogenous materials and substances required by the RoHS directive (the full citation for the current "RoHS Recast" legislation is "Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment").

In this paper, we focus on requirements for tools that enable rapid and accurate reporting of Class D FMDs that can be used by suppliers primarily in the base of the supply chain (e.g., raw materials and smaller components). We also provide examples of how this data can be used by the supplier's immediate customer to build more complex FMD data for product-level assemblies.

Why Take the Road to FMD?

One of the advantages of the FMD approach is that it is the only way a company can stay ahead of the ongoing addition of regulated substances. RoHS has been relatively static in


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this regard—with only changes being to allowable exemptions and additional documentation requirements. Otherwise, the basic six restricted substances have stayed the same from its initial entry into force through its "Recast" in 2011. The next addition of four additional substances, per the European Commissions Delegated Directive 2015/863/EU, will enter into force July 22, 2019. However, customers across the supply chain are already asking for data and compliance conclusions for these substances. This pre-enactment customer driven activity clearly demonstrates just how valuable FMDs can be since suppliers with FMD data can already satisfy their customer's requests about the presence of newly (and yet-to-be) restricted substances.

Since RoHS exemptions have set expiration dates, it is also prudent to know what exempted substance is present, besides just knowing you are compliant with exemption but not exactly why. Since exemptions are substance-specific, this level of information is very useful as a warning that a noncompliance could develop when a product that was once acceptable to ship is no longer compliant because the exemption has expired! FMD data provides the ability to look ahead in time for exemptions that are set to expire, allowing the company to take early action through product redesign or finding alternate suppliers.

REACH (Registration, Evaluation, Authorization and Restriction of Chemicals), promulgated by a separate agency, ECHA (European Chemicals Agency), is much more dynamic and adds new substances of very high concern (SVHC) to the candidate list roughly twice a year ever since 2008. Figure 1 shows the number of substances added to REACH since its beginning in October 2008 through the last date as of this writing. Shorter gray bars count the substances added each date, with the larger black bars indicating the cumulative total of substances.

Note there is some double counting in the Figure 1 data, since a few of the substances were listed a second time due to different toxicological reasons. Also, note that the count is based on just the primary list of SVHC posted by ECHA in its main table, but the actual individual substance count by CAS number is even greater if one consults the ECHA supporting documentation. Further, it is noted that Amendment 3 of IPC-1752A, which is not fully

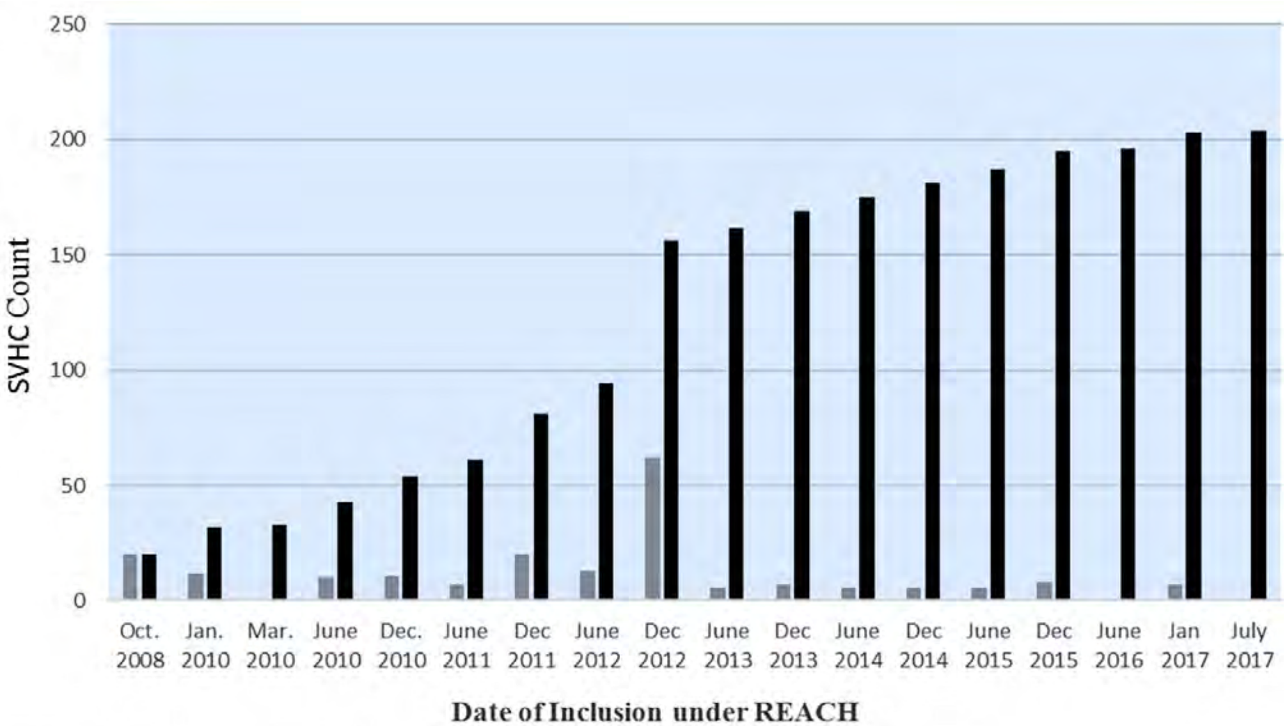

Figure 1: Number of REACH SVHCs from 2008 to present. (Black bars = total; Gray bars = added each date.)

published as of the time of this writing, will contain a non-exhaustive list of substances and their CAS numbers as a convenient reference to this ever-growing list of substances.

Useful information about the standard and its implementation and advantages may be found on the IPC web page, Data Exchange Standards. Additional advantages of FMD have been published, for example, by companies offering such services, companies needing FMDs from their suppliers, industry conferences, and articles in electronics journals[1,2]. The story continues and the message remains clear: Companies need a way to stay ahead of the growing list of new substances they are required to manage. FMDs are the best way to do so.

Requirements Part One: The Schema is the Roadbed

In the next sections, we list and explain the value of functional requirements that a good, basic FMD reporting tool should have. At the most basic level, the tool by its nature will be software, and to be used for reporting up the supply chain the XML declaration file must conform to the IPC standard itself. In recent years, the chairs and participants in the IPC 2-18b Materials Declaration Task Group have graciously offered their time and expertise to help review, on a blind submission basis, XML files including Class D FMDs. Using software tools that are available for checking conformance to the schema as specified in the standard, as well as a review by IPC 2-18b participants, those software solution providers that have been verified in this review process and found to conform to the schema in their test files are listed by IPC.

As the relatively recent history of the IPC review process shows in Table 1, a handful of solution providers have supported and continue to support Class D FMDs, as well as the other reporting classes A and C (not shown). It may be concluded that there are enough competent software solution providers to offer a choice, yet not be overwhelming for companies just embarking on the journey to generate FMDs. Specific company names can be found on the IPC web site as cited above.

Year	Number of Verified Class D Software Tool Providers
2014	7
2015	7
2016	9
2017	11

Table 1: IPC Validated FMD Tool Providers.

Some of the basic requirements for conformance to the standard schema include the following:

- All mandatory data elements (tags) are present, which must be completed when entering data into the tool, if not already present from some prior data entry or load. These elements include data like supplier and customer IDs and part numbers, and homogenous materials in the product broken down by substances and their weights.
- Ability to enter the most useful optional data elements as desired, or as requested by the customer. For example, substance weight is mandatory, but concentration is optional.
- Ability to incorporate a legal statement, either with a standard boilerplate or by entering a custom statement.
- Tags identifying the data as Class D (FMD) based on substance reporting at the homogeneous material level; class C substance category reporting at the product level; or Class A query/reply format (true/false compliance statements).
- Further details including a complete list of mandatory and optional data may be found in the IPC-1752A standard.

Requirements Part Two: Lanes of Chemical Data

Since FMD is all about the chemical data, and suppliers in the electronics industry may not have extensive chemical expertise, this set of functionality is critical to generating Class D XMLs as correct and error-free as possible. Clearly, to even begin generating FMDs requires having the product's chemical composition data, and unfortunately there is no magic to manage this complexity other than a materials and substances database or spreadsheets to manage the list of ingredients to be reported. Some of the major CAD systems are offering functionality to select raw materials from a database coupled to the CAD system, which is logical since the designer is specifying the materials in the first place. More about how to develop basic "what's in the product" documentation may be a good topic for another report, since by some accounts this is still the greatest obstacle to begin any FMD.

Next, we briefly highlight important functional requirements for any tool used to generate FMDs from materials and substance data.

Ability to select substances from a list by 00 number prevents errors, since CAS (chemical abstract service) number is a key for many receiving systems and is the authority tag specified in the IPC standard. A CAS number lookup list should be provided in the tool, which has the advantage of speeding up data entry and selecting matches quickly from valid selections provided by the tool. The tool may also validate the format of the CAS number format itself, which must be 10 digits separated into three groups by hyphens, with the last digit being a check digit. These rules are published by CAS. This type of validation may be useful to allow newer, valid CAS numbers that are not in the lookup table to still be entered. The problem of "wildcard" or declarable/reportable substance lists will be covered in the next section, since it remains a problem in the industry.

A lookup of substance names can also expedite entering substances data, again by ensuring that a valid substance name is used and a valid CAS number goes along with it. The advantage is that a substance name may be more easily recognized and used by a human than a CAS number. This approach to validation has the disadvantage that compounds and even pure elements may have many different synonyms, in which case the direct CAS number lookup would be more useful.

The input screen for materials and substances data may look something like Figure 2. This kind of table is the heart of an FMD, where each material is composed of its constituent substances, all with reported weights in the product. Optionally, data like attachment files and concentration ranges may be accommodated. If exemptions apply at the material level, they may also be selected.

Direct entry into a reporting tool is likely to be of interest to suppliers making raw materials or simple components, rather than OEMs. But this data becomes the basis of creating FMDs for more complex products. Suppliers of the following kinds of items might be in the best position to take advantage of the kinds of tools being discussed here.

- Solder and solder flux (separately or in paste or wire)
- Bulk material like sheets, or parts made of a homogenous material
- Metal alloys, or parts made from them
- Wire
- Mold compound; molded parts
- Underfill
- Conformal coating
- Plating, painted or dipped coating, or other types of coating
- Adhesives, lubricants or sealants

FMDs for these items can allow the next tier customer to use it for reporting at the next assembly level. Companies on the more complex end of the supply chain may need to use larger enterprise systems to collect this data and run final reports, so the more basic FMD generating tools may be of less interest to them. Figure 3 shows how the data cascade

	Homogeneous Mat.	Mass	UoM	Attach.		Level	Substance Category		CAS	Substance	Exemption	Mass	UoM	Min. Conc.	Max. Conc.
+ -	Filled Plastic	1	g	Browse ...	+ -			+ -	9003-56-9	2-Propenenitrile, poly		0.8	g		
								+ -	14808-60-7	Quartz (SiO2)		0.2	g		

Figure 2: Example of material and substance input screen.[3]

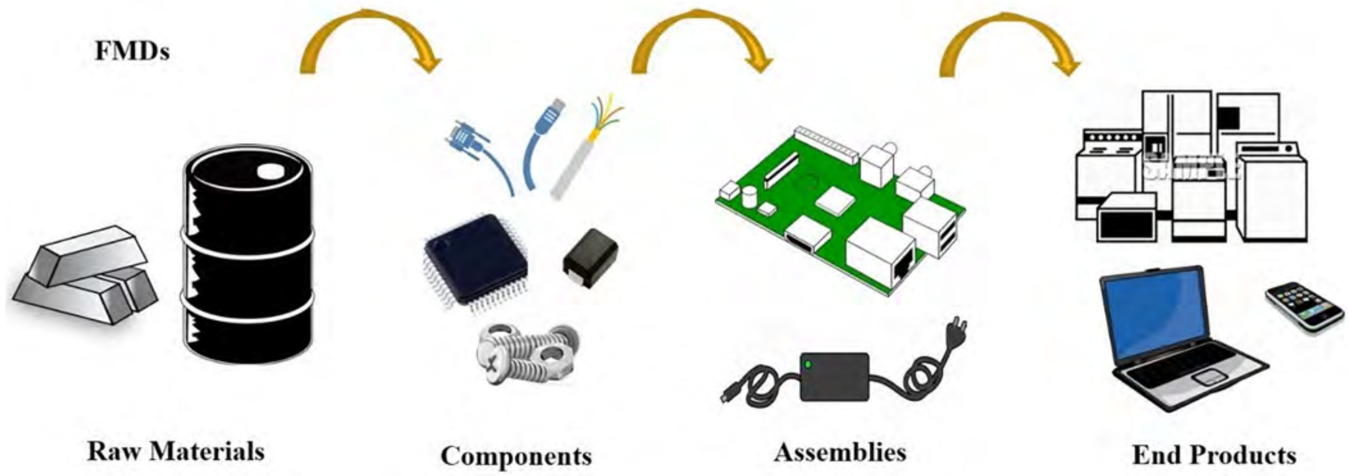

Figure 3: Cascade of FMD data.

works. As originally envisioned with the first release of IPC-1752 in 2006, the data cascade is still deserving of more widespread understanding and more thorough implementation today. We realize the complexity of electronic products, since even small personal use devices may contain hundreds to thousands of components, the key point here is that having good tools at the very beginning stage can be useful as the data builds in complexity up to reports for more complex products.

Requirements Part Three: The Wildcard Detour

By necessity, companies and standards organizations themselves have used Reportable or Declarable Substances Lists (DSL) for years. One of the early lists was the Joint Industry Guide (JIG) which went through several updates. Amendment 3 to IPC-1752A includes the following statement: The IEC 62474 database of restricted and declarable substances replaced the Joint Industry Guide in January 2014.

Meanwhile, most companies have created their own DSLs so that they will receive:

- Data on those substances currently with regulatory restrictions
- Data on industry-specific substances
- Data on other substances the company's customers expect to know about
- Substances that are not yet under any regulatory restrictions, but could be at some future date

This latter case is exactly the REACH situation shown at the beginning of this paper. While there are some ways to get advanced information about the next substances to be added to REACH, these are not usually foolproof. Therefore, companies tend to cast a rather wide net to ensure future substances are being included in their suppliers' declarations.

The IEC62474 database as of this writing was most recently revised on September 3, 2017 and contains 137 declarable substances and 482 reference substances. Many companies have nonetheless found it necessary, for the reasons listed above, to develop more comprehensive lists of their own. Without mentioning specific company DLSs here, a general review of some of the many that are used in the electronics industry shows two basic trends:

- Substances listed in common as a core set of substances, including those in common with the IEC62474 list
- Substances that are less frequently found and not part of a common core list

Since homogeneous material reporting is at the substance level, with authority being the CAS number, this presents a data handling/segregation dilemma.

In a good reporting tool, then, some accommodation must be made for accepting these "wildcard" substances which inherently have no CAS number. We have seen a commonly but not universally accepted limit of 10% per homogenous material can be checked in the tool to ensure this limit is not exceeded. A good tool should also allow for a choice of a customer-specific wildcard substance name, which is not subject to checking from a CAS number list or a CAS format validation routine. Based on our review, if proper warnings are provided, this appears to be the best way at present to handle such data.

Requirements Part Four: Fewer Barriers, More Open Road

So far, we have presented desirable features to help generate FMDs. The real power, though, is only realized through ability to revise, reuse, and build on data once it has been initially entered into a tool.

First of these capabilities is ability to quickly edit the substances in a material. For companies making a family of items with related composition, changing just a few entries, or modifying the percentages of them, can be done in seconds and saved under a different product name and XML file, with version tracking as desired in the file name. This should be allowed during an existing session or combined with the next feature.

Once a complete XML FMD is generated, productivity is enhanced if that file can be easily imported again at a later date and edited as required. This portability and flexibility of data allows a supplier further down the supply chain to utilize a growing library of common materials and their formulations, and to quickly create new ones without having to repeat some or even most of the data entry. In most cases, the company's own information, like company ID, contact and authorizer, will be repeated over many declarations. If contact and authorizer are the same person, they could be copied directly with a choice in the tool.

While we are focusing here on the Class D FMD, ability to generate Class A or Class D declarations at the same time may be useful. These should be selected, or de-selected as desired, or as required by the customer. Class A query/response answers should be straightforward, as should selection of exemptions from a list. Similarly, the substance data in the Class D data section should be quickly erased to enter fresh data while retaining the rest of the information already entered.

Interactive helps should provide guidance to first time and infrequent users. Checks along the way improve speed and accuracy without having to consult a user's manual, which incidentally should also be easily accessible for those who wish to read the instructions first. Finally, the tool should prevent hang-ups and errors. Support services should be provided, and a process to investigate and resolve bugs, or perceived bugs, should be easy to submit and provide timely responses.

At the end of data entry there should be a final validation of the XML, included mandatory information has been entered and the weights of substances add up to each homogenous material being reported. These checks help ensure that the XML will successfully load to the customer's system.

Conclusions: To the Superhighway

According to some observers, FMD still has too many barriers to really catch on. We disagree. Supply chain reporting has to begin somewhere, by providing data to middle supply chain companies, and so forth up to chain to the OEM. FMD is the only reporting approach that helps to minimize the ongoing burden of keeping up with the ever-growing lists of regulated substances and expiring exemptions.

We have mentioned that the IEC 62474 database is now invoked as the reportable substance list in IPC-1752A Amendment 3. In addition, development of an IEC 62474 international standard for reporting is in process, which will also specify an XML format. Work is underway to harmonize the schema of both IPC and IEC standards via communication and common participants in both IPC and IEC standards development, but differences should still be expected. Development of the IEC reporting standard nevertheless underscores the interest and need for FMD realization in XML format.

Further enhancements can also be realized in the future. To name a few:

- Integration with manufacturing data for mixed, compounded or formulated materials
- Availability of integrated materials selection with design tools for more complex products
- True business-to-business methods to request data as well as provide data all in standard machine-readable formats
- Enhanced error checking, validation of common-sense rules, and agreement between, for example, a Class A declaration that says RoHS Compliant = True, yet the Class D file for the same item reports a RoHS substance over the threshold percent
- Support for updated guidance from ECHA on Once an Article, Always and Article, which changes substance percent reporting from any top-level assembly to the lowest level article exceeding the 0.1% SVHC threshold. It is becoming clear that this will require a new data attribute to flag articles, as distinct from unshaped materials or complex objects. It is our understanding that this will be considered in the development of a revised IPC-1752B Standard

In addition to the motivation of staying ahead of the growing number of regulated substances, business processes and procedures that support FMD can also be useful. The expectation that FMDs must be provided can be a requirement for gaining new business or for qualification of an item as a prerequisite to be purchased. A company can also include FMD responsiveness in ongoing supplier evaluation performance ratings that may influence awarding future business. Once an FMD is received in well-formed XML format, loading this data to the customer's system can be automated for maximum efficiency and reused through the FMD cascade process. We have seen it work and only need more FMDs entering the road. **SMT007**

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1. M. Myles, Supply Chain Data Exchange for Material Disclosure. Journal of Surface Mount Technology, Vol. 19-1, 2006.
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This paper was first presented at the 2018 IPC APEX EXPO Technical Conference and published in the 2018 Technical Conference Proceedings.

Roger L. Franz is an engineering system analyst at TE Connectivity.

Seeing Clearly: XR Headsets and Flex's Reference Design at AWE

by Dan Feinberg, I-Connect007

At the recently concluded Augmented World Expo (AWE) in Santa Clara, California, Flex invited I-Connect007 to attend an event where they presented an update on their XR progress since the Consumer Electronics Show (CES) in January. At this year's CES, they announced the launch of an extended reality (XR) reference design for the next generation of XR headsets. The company has now introduced an augmented reality (AR or, as we now call it, XR) reference design to reduce time to market for companies wishing to make and market XR devices.

Read the full article here.

Recent Highlights from SMT007.com

1 Combining Strengths Synergistically: PDS and Green Circuits


Joe O'Neil, Power Design Services

Power Design Services (PDS) and Green Circuits have just announced their merger. I-Connect007 Publisher Barry Matties recently sat down with Joe O'Neil and Matthew Becker of PDS, along with Ted Park of Green Circuits, to get the full scoop.

2 Green Circuits and Power Design Services Merge to Form EMS Powerhouse

In order to continue to meet the ever-expanding requirements of the manufacturing industry, Power Design Services (PDS) and Green Circuits have entered into a merger agreement effective May 21, 2018.

3 The Survey Said: Industry Optimistic After Strong 2017

During recent trade shows and conferences, we spoke with a variety of fabricators and assembly providers. They had one thing in common: Every company achieved strong growth in 2017, and shared a positive outlook about the future. This year, the industry is optimistic, driven by positive economic outlook, growing customer demand, and new technologies and vertical markets, among others.

4 IPC Automotive Electronics Reliability Forum Highlights Future of Industry

Fueled by strong growth in electric vehicles and autonomous cars, and a dramatic increase in electronics content in conventional automobiles and trucks, automotive electronics are crucial components of engine, ignition, and transmission management; entertainment, navigation, diagnostic tools and safety systems.

5 Sharp to Acquire Toshiba PC Business and Help Foxconn Diversify ▶

Sharp is acquiring Toshiba's personal computer business, bringing new dynamics to the notebook market. Sharp has shuttered its own PC business previously, but this deal may be associated with the strategic development of Foxconn Technology Group, says WitsView, a division of TrendForce.

6 Jabil Speeds Digital Transformations ▶

Jabil has announced enhancements to its suite of industry-leading procurement capabilities to help global organizations minimize risk, optimize production and achieve cost leadership. Additionally, the company introduced its new Radius Digital Strategy Practice to assist customers in navigating complex digital transformations while creating business value and brand differentiation.

7 Kimball Electronics to Acquire Global Equipment Services ▶

Kimball Electronics Inc. has signed an agreement to purchase substantially all of the assets and assume certain liabilities of GES Holdings Inc., Global Equipment Services and Manufacturing Inc., and its subsidiaries, for approximately $50 million plus the assumed liabilities.

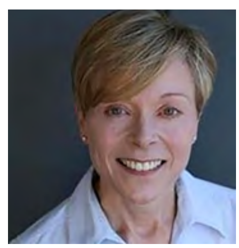
8 Electronics and Textiles Come Together at IPC E-Textiles 2018 ▶

If your company has e-textiles and/or stretchable technologies on its roadmap and you find yourself asking the question, "How can I merge smart fabrics with smart engineering?" IPC has developed a technical and business education workshop to answer these questions and more.

9 Cirtronics Hosted Panel at Inaugural Robotics Summit and Showcase ▶

Cirtronics has hosted a panel of three senior executives from local robotic companies for the inaugural Robotics Summit and Showcase recently held in Boston.

10 Benchmark Electronics Appoints Merilee Raines to Board ▶



Benchmark Electronics Inc. has appointed Merilee Raines as an independent director to the board of directors of the company effective May 18, 2018.

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IPC E-Textiles 2018 Workshop ▶

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October 14–18, 2018
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November 13–15, 2018
Illinois, USA

electronica 2018 ▶

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PUBLISHER: **BARRY MATTIES**
barry@iconnect007.com

SALES MANAGER: **BARB HOCKADAY**
(916) 608-0660; barb@iconnect007.com

MARKETING SERVICES: **TOBEY MARSICOVETERE**
(916) 266-9160; tobey@iconnect007.com

EDITORIAL:
MANAGING EDITOR: **STEPHEN LAS MARIAS**
+63 906 479 5392; stephen@iconnect007.com

TECHNICAL EDITOR: **PETE STARKEY**
+44 (0) 1455 293333; pete@iconnect007.com

MAGAZINE PRODUCTION CREW:
PRODUCTION MANAGER: **SHELLY STEIN**
shelly@iconnect007.com

MAGAZINE LAYOUT: **RON MEOGROSSI**

AD DESIGN: **SHELLY STEIN, MIKE RADOGNA, TOBEY MARSICOVETERE**

INNOVATIVE TECHNOLOGY: **BRYSON MATTIES**

COVER: **SHELLY STEIN**

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EDITORIAL CONTACT
Stephen Las Marias
stephen@iconnect007.com
+63 906-479-5392 GMT+8

SALES CONTACT
Barb Hockaday
barb@iconnect007.com
+1 916 365-1727 GMT-7

www.iconnect007.com